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AUTOMATION ON THE MANAGEMENT PROCESS

by

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CHAPTER I

INTRODUCTION

Purpose and Scope of the Study

The effects of automation have been most often discussed in macro terms, e.g., the effects on the economy, the effects on the labor force, and the impact on education. There have been numerous books and articles written concerning technological displacement, the problem of leisure and other possible effects of automation on workers. Governmental interest has been evidenced by congressional hearings on the economic and manpower aspects of automation; by the establishment of a presidential commission to "determine the impact of automation and technological change on the economy;"[1] and by contract studies on certain economic and social effects of automation. In addition, the macro-effects of automation on society have been debated at a number of conferences and seminars, often sponsored by educational and other non-government organizations.

Management has not been over-looked in these efforts, but the impact of automation on management appears to have

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[1] Howard R. Bowen and Garth L. Mangum, eds., *Automation and Economic Progress* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966), p. 2.

been among the least explored aspects of automation. The broad hypothesis underlying this study is that the introduction of automated production systems will affect the responsibilities, roles and activities of management. John Diebold states:

> The accelerated pace of technological change poses a serious challenge to management. Attention is commonly focused on the problems involved in putting new innovations to work and on the imbalances created by such implementation. Perhaps even more far-reaching in its impact on today's manager is the effect technology is having on the very process of management itself.[2]

The purpose of this study is the investigation of certain effects of production automation on the process of management in terms of the managerial functions of planning, controlling, organizing, staffing and directing. It is hoped that the findings will make some contribution toward a better understanding of automation management.

Automated systems would include, of course, those installed in banks, insurance companies, and large retail organizations and the "office automation" of many firms--manufacturing and otherwise. The scope of this study does not include non-manufacturing firms nor does it include an analysis of the effects of "office automation." It is confined to the investigation of certain effects of production automation in manufacturing firms.

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[2]John Diebold, Beyond Automation (New York: McGraw-Hill Book Company, 1964), p. 15.

Research Methodology

This study is concerned with how the managerial functions of planning, controlling, organizing, staffing and directing are affected by automating production. In order to provide a foundation for the study an extensive review of the relevant literature was undertaken. The University of Georgia Library was used as the primary source of materials for the review of the literature. The library resources of the University of Georgia Center for the Study of Automation and Society were also used. Additional literature was made available from the private collections of several individuals currently active in the field of automation. The report of the review of the literature is contained in Chapter II.

In order to provide a framework for the main research effort certain sub-functions or elements of each of the five major managerial functions were identified for investigation. It was determined that the most practical means of obtaining data was by a survey of selected companies and individual managers. Two questionnaires were developed based on the managerial sub-functions or elements identified for investigation. The questionnaires were placed in final form with the aid of members of the writer's graduate committee.

A group of 990 manufacturing companies was selected to receive the questionnaire developed for companies to answer. These 990 companies were selected from the 32,600 firms listed in the Dun and Bradstreet Million Dollar and

Middle Market Directories. Each questionnaire was accompanied by a cover letter explaining the purpose of the study and requesting the company's cooperation. The cover letter is contained in Appendix A. Of the 990 companies to which questionnaires were sent, 247 companies responded with useful information prior to the cut-off date. Thus a useful response rate of 24.9 per cent was experienced. Categorizing these 247 companies by "automated" and "non-automated" production processes resulted in 131 companies (53 per cent) falling in the automated group and 116 companies (47 per cent) in the non-automated group. Companies which checked either A or B in response to Question 2 were placed in the automated group. Companies which checked C or D were placed in the non-automated group. The complete questionnaire to companies is presented below.

QUESTIONNAIRE

1. Name and address of company:

2. Is your production process: (check one)

    _____A. Automated

    _____B. Partially automated

    _____C. Mechanical

    _____D. Manual

3. Does your company have a written corporate plan?

    Yes_____ No_____
    If the answer to this question is "yes," what future time period or periods does your plan include--i.e. 1 yr., 5 yr., 1 yr. and 5 yr., etc.?

4. Does your company have a written statement of objectives and goals?

Yes_____ No_____
If your answer to this question is "yes," would you please enclose a copy of your statement of objectives.

5. Indicate by check-marks which of the following types of forecasting activities your company engages in; also please indicate how often forecasts are made and the length of the forecasts.

	Type of forecast	How Often	Length of forecast
_____A.	Sales forecast	_____	_____
_____B.	Production forecasts	_____	_____
_____C.	Profit forecasts	_____	_____
_____D.	Manpower requirements	_____	_____
_____E.	Financial requirements	_____	_____
_____F.	Equipment requirements	_____	_____
_____G.	Facility or plant requirements	_____	_____
_____H.	Technological forecasts	_____	_____
_____I.	Other (please explain)	_____	_____

6. Indicate by check-marks which of the following planning or decision making techniques your company makes use of:

_____A. Bayesian statistics

_____B. Breakeven chart analysis

_____C. Cost/Benefit analysis

_____D. Critical path methods (PERT/COST, etc.)

_____E. DELPHI

_____F. Economic lot size model

_____G. Economic order quantity model

_____H. Game Theory

_____I. Gantt Chart

_____J. Linear programming

_____K. Markov-chain analysis

_____L. Non-linear programming

_____M. Probability Theory

_____N. Queuing Theory

_____O. Regression/Correlation analysis

_____P. Return-on-investment analysis

_____Q. Simulation

7. How does your company measure the organization's performance? Using the following list of performance measures, select and indicate by check-marks, the five (5) which are most important for your company:

_____A. Absenteeism

_____B. Community and public responsibility

_____C. Corporate growth

_____D. Customer satisfaction

_____E. Employee turnover

_____F. Increasing production

_____G. Innovation

_____H. Loyalty of employees

_____I. Market standing

_____J. Productivity

_____K. Profitability

_____L. Quality of output

_____M. Reducing costs

_____N. Return on investment

_____O. Safety record

_____P. Sales

_____Q. Other (describe)

8. Which of the following descriptions best characterizes your Management Information System?

_____A. Manual data processing

_____B. Mechanical data processing

_____C. Electromechanical data processing

_____D. Electronic data processing--batch system

_____E. On-line, real-time electronic data processing

9. For your production workers what type or types of wage payment plans do you use? Using the following list indicate the one or more types of plans that you use.

_____A. Daywork

_____B. Piecework

_____C. Group plan

_____D. Other (please explain)

10. Would you please attach to this returned questionnaire a list of occupational skill classifications for your production employees, showing the number of employees in each skill. Please use the standard classifications from the U.S. Department of Labor Dictionary of Occupational Titles. For example: 585.380 Cutting-machine fixer (textile).

A group of 495 individual managers in 50 manufacturing firms was selected to receive the questionnaire developed for managers to answer. These managers were selected from Poor's Register of Corporations, Directors and Executives and by direct contact with top management of certain other selected companies. Each questionnaire was accompanied by a cover letter explaining the purpose of the study and requesting the manager's cooperation. The cover letter is contained in

Appendix B. Of the 495 managers to which questionnaires were sent, 216 managers returned usable data prior to the cut-off date--a useful response rate of 43.6 per cent. Of these 216 managers, 116 (53.7 per cent) were from firms with automated production, and 100 (46.3 per cent) were from non-automated firms. Those indicating A or B in response to Question 2 were placed in the automated group, and those checking C or D were placed in the non-automated group. The complete questionnaire to managers is presented below.

QUESTIONNAIRE

Part I

1. Name and address of your company:

2. Is the production process in your company: (check one)

______A. Automated

______B. Partially automated

______C. Mechanical

______D. Manual

3. Your age: ______

4. What is your present position with the firm?

5. How long have you been in your present position with the firm? ______

6. How long have you been with your firm? ______

7. What is your total number of years of managerial experience? ______

8. Please indicate your educational background by checking the appropriate item below:

______A. High school or less

_____B. Some college

_____C. College graduate

_____D. Some postgraduate work

_____E. Masters degree

_____F. Ph.D.

9. If you are a college graduate, please indicate what degree or degrees you hold and the major field of study for each degree:

Part II

For each of the following eight statements please indicate your degree of agreement or disagreement by checking the expression which best reflects your opinion:

1. The department head alone should determine the methods to be followed in attaining departmental goals and objectives. Strongly disagree_____; Disagree_____; Uncertain_____; Agree_____; Strongly agree_____.

2. Most employees feel unduly burdened if they are given added authority and responsibility.
Strongly disagree_____; Disagree_____; Uncertain_____; Agree_____; Strongly agree_____.

3. A manager can make effective use of the authority he possesses due to his position in the organization only to the degree to which he is accepted by his subordinates.
Strongly disagree_____; Disagree_____; Uncertain_____; Agree_____; Strongly agree_____.

4. The personal goals and needs of employees are satisfied if they are paid adequate wages.
Strongly disagree_____; Disagree_____; Uncertain_____; Agree_____; Strongly agree_____.

5. Most employees will exert their fullest cooperation and effort if they are allowed to take part in and are given responsibility in making decisions that affect their work.
Strongly disagree_____; Disagree_____; Uncertain_____; Agree_____; Strongly agree_____.

6. Close supervision is desirable in the interest of efficiency. Strongly disagree_____; Disagree_____; Uncertain_____; Agree_____; Strongly agree_____.

7. Most employees crave increasing responsibilities and independence.
Strongly disagree_____; Disagree_____; Uncertain_____; Agree_____; Strongly agree_____.

8. Before making the final decision himself, the manager should first let his subordinates search the various alternatives and evaluate their consequences.
Strongly disagree_____; Disagree_____; Uncertain_____; Agree_____; Strongly agree_____.

Part III

What motivational factors do you feel contribute most positively to job satisfaction among employees? Please answer this question by use of the following list of motivational factors. From the list choose the five (5) factors which you believe contribute most positively to job satisfaction and indicate your choices by check-marks.

_____Achievement

_____Advancement

_____Company policy and administration

_____Opportunity for personal growth

_____Recognition for achievement

_____Relationships with other employees

_____Responsibility

_____Salary

_____Security

_____Status

_____Supervision

_____Working conditions

_____The work itself

Limitations of the Study

There are two major limitations of this study. First is the fact that the group of companies selected as well as the companies from which the group of managers was selected are heterogeneous with respect to industry and product classification. There are differences in production automation between industries and from one product to another. It is well known that production automation in the petroleum industry is quite different from automation in the metal working industries. Within the metal industries the automatic production of wire in a continuous strip is a process very different from the automatic production and assembly of automotive engines. Because of these differences between automated processes, the effects of automation on management may vary from industry to industry and from product to product. This study was undertaken with this possible limitation in mind. However, a fundamental assumption was made that while the companies surveyed may be heterogeneous in terms of industry and product classification, the management of these companies is close to homogeneous based on the principle of the transferability of management and the universality of the major functions of management. The study of the effects of production automation on management within given industries is an area for further research.

The other major limitation is that the study does not account for the effects of company size on management for

the functions, sub-functions and elements investigated. It is quite likely that size of the firm does have an effect, for example, on the extent of long range planning. The realities of the research situation precluded measuring the effects of size. This too is a possible area for further research.

The Order of the Study

The subsequent material of this study is organized in the following manner.

Chapter II presents a review of the relevant literature including sections on the definition, history, and state-of-the-art of automation. This chapter also includes a discussion of the parallel development of the management process and technology.

Chapters III, IV, V and VI contain the report of the primary research effort conducted in conjunction with the study. These chapters are concerned with the effects of production automation on the managerial functions of planning, controlling, organizing and staffing, and directing respectively.

Chapter VII completes the study by giving a summary and the significant conclusions. Certain illustrative materials are presented in the Appendix.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Technological change in the form of automation has received increasing attention in recent years among men of academia, government, industry and labor. The increased interest in automation is manifested by numerous books and articles written on the subject, by congressional hearings, by government contract studies undertaken, by the establishment of labor committees to evaluate the impact of automation, and by a number of conferences and seminars on automation sponsored by educational and other non-government organizations. It has been said that the world is experiencing a "second industrial revolution" which might be appropriately termed "the era of automation."[1] Some have called this a mental revolution to distinguish it from the first industrial revolution which extended and replaced the muscle power of men and animals with machines.[2] Now, certain mental functions can be taken over by automation devices such as electronic computers and feedback-controlled transfer machines.

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[1]William Francois, Automation: Industrialization Comes of Age (New York: The Macmillan Company, 1964), p. 22.

[2]Edward B. Shils, Automation and Industrial Relations (New York: Holt, Rinehart and Winston, Inc., 1966), p. 4.

Continuous advance in manufacturing technology has been a major factor in man's climb toward a more productive civilization. Automation signals a significant advance in production technology. Made possible largely by advances in electronics, automation is a complex technology, employed in such systems as automatic transfer and assembly in the metal working industries and the continuous flow processes of the petroleum and chemical industries.

Observers are divided in their attitudes about the consequences or effects of automation. Discussion and debate range over a broad spectrum of social and economic questions related to automation. This dissertation is limited to a study of certain effects of industrial production automation on management. The purpose of this chapter is to review the relevant literature to provide a foundation for the study.

The Problem of Definition

Automation is no longer a new subject and yet a multiplicity of definitions continues to cause semantic confusion. The Clark Committee on Manpower Policy of the United States Senate observed:

> This lack of understanding (of the impact of technological change) stems from a confusion of tongues--a failure to define terms and a tendency to lump all technological developments under one increasingly meaningless term: automation. A paucity of statistical data and a tendency to ignore that which does not square with cherished preconceptions is also to some extent responsible. A final element has been the

natural tendency of every expert to examine only his own part of the elephant.[3]

The confusion surrounding the word "automation" is such that it has been used to characterize technology as both an evolutionary and a revolutionary process, to describe the novelty of arrangements that link one machine with another, and to denote the unusual capabilities of engineering forms, particularly those that improve upon the contributions to productivity otherwise made by labor. The term has been used to describe almost every economic change that might be contemplated, including changes in plant layout, product design, job design and methods for quality control,[4] as well as the application of electronic computers to non-manufacturing processes, often referred to as "office automation."

Adding to the confusion, has been the tendency to use the word "automation" to suit a variety of vested interests. It has been used as a technological rallying cry, a manufacturing goal, an engineering challenge, an advertising slogan,

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[3] U.S., Congress, Senate, Subcommittee on Employment and Manpower of the Committee on Labor and Public Welfare, Toward Full Employment: Proposals for a Comprehensive Employment and Manpower Policy in the United States, 88th Cong., 2d Sess., 1964, p. 15.

[4] Paul E. Sultan and Paul Prasow, "Automation: Some Classification and Measurement Problems," Automation: A Discussion of Research Methods. Labor and Automation Bulletin No. 1 (Geneva: International Labor Office, 1964), pp. 9-10.

a labor campaign banner, and as the symbol of ominous technological progress.[5]

Part of the confusion can be traced to the origin of the word "automation." Two men are claimants to authorship of the term. D. S. Harder, a Ford Motor Company executive, and John T. Diebold, a well-known management consultant, coined the word independently of each other and gave it different meanings. Harder is said to have first used the word in late 1946 to describe automatic transfer of workpieces from one machine to another in the production process without human aid. He was referring to the automatic removal of sheet metal stampings from heavy presses by mechanical hands and arms.[6] John Diebold coined the term as a contraction of the word "automatization" which he found too awkward and too difficult to spell.[7]

In the aftermath of this dual origin of the term automation, a profusion of definitions has been forthcoming. Furthermore, it is apparent that the word is often used as a synonym for technological advance. Therefore, it seems desirable to review the definitions which have been offered

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[5] James R. Bright, Automation and Management (Norwood, Massachusetts: The Plimpton Press, 1958), p. 4.

[6] H. Douglass Rowe, Automation to Date, American Management Association Manufacturing Series No. 209, p. 24.

[7] John T. Diebold, Automation, The Advent of the Automatic Factory (New York: D. Van Nostrand Co., 1952), p. ix.

and to discuss the distinctions between technological advance and automation which have been suggested.

To Harder, the word originally meant the mechanized handling of materials or parts between, into, and out of machines. This concept has been labeled "Detroit automation." Automation by this definition can be narrowed to specific conveyor equipment. Diebold has a somewhat broader concept of automation:

> Automation is a new word denoting both automatic operation and the process of making things automatic. In the latter sense it includes several areas of industrial activity such as product and process redesign, the theory of communication and control, and the design of machinery.[8]

Harder later modified his original concept of automation. He concludes that it is a "philosophy of manufacturing" and believes that the original definition must be broadened to include the design of parts, methods for their manufacture, and production tool control systems.[9]

Open-loop and Closed-loop Control

Diebold, in elaborating on his concept of automation, states that "automation is possible only through use of the recently acquired ability to design and construct a wide variety of closed-loop control systems."[10] Underlying this

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[8] Ibid.

[9] Anderson Ashburn, "Automation--Its Development in Metalworking," Mechanical Engineering (November, 1955), p. 960.

[10] Diebold, op. cit., p. 13.

statement is a key concept in complete automation--that is the replacement of the human mental function with automatic controls. There are two basic types of control--open-loop and closed-loop, illustrated in Figures 1 and 2 respectively. The main difference between these two types of control is that if the function of controlling a process is not completely automatic, so that a human operator must adjust the process, then the operation has an open-loop control. In the open-loop system the human being controls by visual or other inspection methods to measure deviations and make corrective adjustments. The most important control characteristic from the standpoint of automation, the ability to automatically correct errors, is not present in open-loop systems. In a closed-loop system a completely automatic controlling device fills the gap represented by the worker in the open-loop system. The essential features are the automatic measurement of output, sensing unacceptable deviations and issuing corrective orders to the machinery or equipment being controlled.

The closed-loop aspect of automation draws heavily on the concepts of "cybernetics." The word, "cybernetics," was coined by Dr. Norbert Wiener to mean "the entire field of control and communication theory, whether in the machine or in the animal."[11] Wiener explains the feedback principle in

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[11] Norbert Wiener, Cybernetics (New York: John Wiley and Sons, Inc., 1948), p. 19.

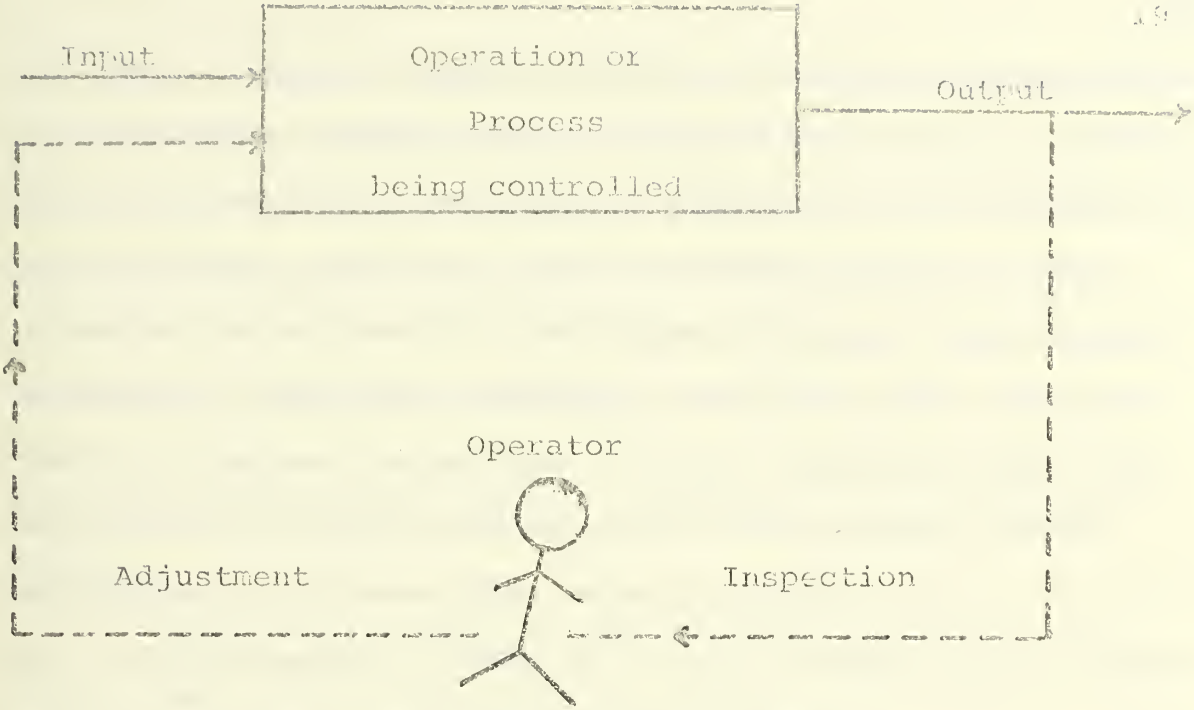

Figure 1. Open-loop control system.

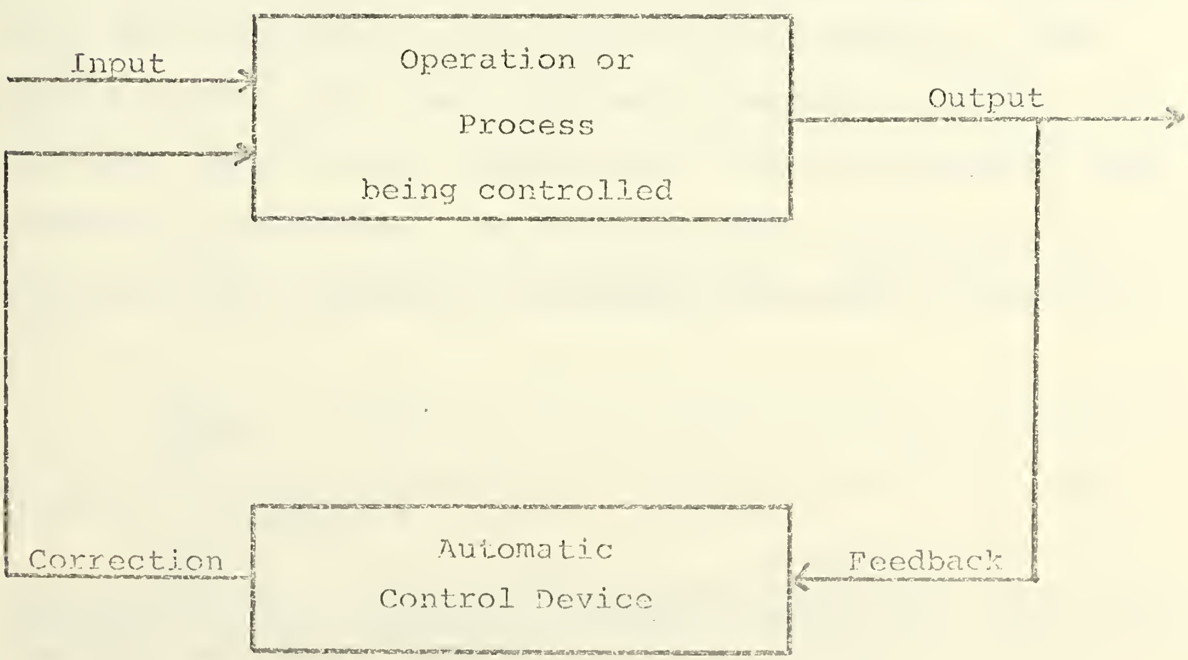

Figure 2. Closed-loop control system.

this way: "When we desire a motion to follow a given pattern the difference between the pattern and the actually performed motion is used as a new input to cause the part regulated to move in such a way as to bring its motion closer to that given by the pattern."[12] According to Wiener, the steering engines of a ship are examples of early and well developed forms of feedback mechanisms.[13] While expressing some concern about the understanding of the relationship between automation and cybernetics, Albert F. Sperry points out that we find cybernetics thought of as just another phase of automation.[14] Bright reflects a similar view:

> Thus "cybernetics," the "automatic factory," and "automation" began to be blended in general usage as interchangeable phrases or parallel concepts, implying a wave of automaticity and the mechanization of control and many mental processes.[15]

Another approach to the relationship between automation and cybernetics, that centers on the degree of automation allowed, has been proposed by Donald N. Michael. He contends that the word "automation" does not typically imply computer applications. To delineate that situation, he proposes that information technology involving the use of

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[12] Ibid., p. 13.

[13] The word "cybernetics" is derived from the Greek word for "steersman."

[14] Albert F. Sperry, "The Nature of Automation," Keeping Pace with Automation, Special Report No. 7 (New York: American Management Association, 1956), p. 14.

[15] Bright, op. cit., p. 6.

computers (labeled "cybernetics") he joined with automation under the term "cybernation." Viewed in this way, any automatic control mechanism involves automation, but when the control functions involve the use of computers, including numerical control of production operations or other hybrid applications, then that is cybernation.[16]

Proposed Distinctions Between Automation and Technological Advance

Regarding the problem of synonymous usage of "automation" and "advanced technology," Sultan and Prasow discuss classification systems proposed by Killingsworth[17] and Buckingham[18] which help to clarify the distinction. In Killingsworth's system changes of economic activity are viewed as a series of concentric circles, with the outside circle representing all forms of economic change. Such activity is affected by changes in the availability of resources, changes in trading boundaries, the development of

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[16] Donald N. Michael, Cybernation: The Silent Conquest (Santa Barbara: Center for the Study of Democratic Institutions, 1962), p. 6.

[17] U.S., Congress, Senate, Subcommittee on Employment and Manpower of the Committee on Labor and Public Welfare, Nations Manpower Revolution, 88th Cong., 1st Sess., 1963, Part 5, pp. 1462-1466.

[18] Walter S. Buckingham, Jr., "Automation, Employment and Economic Stability," Automation and Society, eds. Howard B. Jacobson and Joseph S. Roucek (New York: Philosophical Library, 1959), pp. 231-233; Walter S. Buckingham, Jr., Automation: Its Impact on Business and People (New York: Harper & Row, 1963), pp. 11-48.

new and substitute products, changes in the mix of resources used in production, or changes in managerial efficiency. Within this circle is technological change, defined as inventive activity such as the use of pure oxygen in steelmaking. In effect, it represents changes in those capital forms through which economic resources are transformed into goods and services. Contained within the circle of technological change is the circle of mechanization, a specific kind of change in production technique. This involves the application of machinery to tasks formerly performed by human or animal labor or the application of labor-saving techniques. In this classification system, automation is represented as the core circle, and is defined as engineering forms that increase the degree of self-regulation of the mechanization process. It is conceded, however, that the perimeters of the circles cannot always be clearly established and the fuzziness of the distinction becomes greater as the core circle of automation is approached. In reality there is a considerable range to the degree of sophistication and the form of such regulating mechanisms.[19] Nonetheless, this classification system contributes to an understanding of the essential distinctions between automation and advanced technology.

Similar distinctions have been proposed by Walter Buckingham. In his system of classification, technology

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[19] Sultan and Prasow, *op. cit.*, p. 16.

encompasses mechanization, mass production and automation, evolving historically in that order. Mechanization involved the use of machines to perform work; mass production involved a new technique for organizing for production; and automation is a technology based on communication and control.[20]

These efforts to isolate the distinctive elements of automation stress the self-regulation of the production process.

Other Definitions of Automation

Numerous others have offered definitions of automation. Soon after Harder coined the word Rupert Le Grand, Associate Editor, "American Machinist," defined automation as:

> .....the art of applying mechanical devices to manipulate work pieces into and out of equipment, turn parts between operations, remove scrap, and to perform these tasks in timed sequence with the production equipment so that the line can be put wholly or partially under push-button control at strategic stations.[21]

A definition proposed by Milton Aronson is more precise in defining the motives and devices used in automation. His definition states that "automation is the substitution of mechanical, pneumatic, hydraulic, electric, and electronic devices for human organs of decision and effort."[22] This

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[20] Ibid.

[21] Rupert Le Grand, "Ford Handles by Automation," American Machinist, Vol. 92, No. 22 (October, 1948), pp. 107-122.

[22] Milton H. Aronson, "Automation and Economics," Instruments and Automation (June, 1955), p. 893.

definition includes and yet differentiates between, decision devices such as computers and effort devices--e.g. conveyors, valves and motors. It also points out that specific devices used in automation are mechanical, pneumatic, hydraulic, electric and electronic in nature--thus emphasizing that such devices are not primarily either mechanical conveyors or electronic computers.

In hearings before a congressional subcommittee to explore the nature and implications of automation a number of prominent witnesses stated their concepts of automation. Ralph Cordiner said that, "For practical purposes in planning manufacturing facilities, General Electric defines automation as 'continuous automatic production,' largely in the sense of linking together already highly mechanized individual operations. Automation is a way of work based on the concept of production as a continuous flow, rather than processing by intermittent batches of work."[23] Dr. Edwin G. Nourse, former chairman of the council of Economic Advisors, viewed automation as a continuation of the scientific management movement but emphasized the new application of electronics to the control of mechanical and chemical processes: "(automation) has its roots in mechanization, to be sure, but something new was added when electronic devices made

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[23]U.S., Congress, Joint, Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report, Hearings, Automation and Technological Change, 84th Cong., 1st Sess., 1955, p. 424.

possible the widespread application of the feedback principle."[24] Walter Reuther expressed his concept of automation as:

> ...Automation is the second phase of the industrial revolution....Automation makes a completely new development in the technological process because automation, in addition to substituting mechanical power for human power, begins to substitute mechanical judgment for human judgment--the machine begins to substitute the thinking process on a mechanical basis for the thinking process which heretofore was done exclusively by the human mind.[25]

In a more recent definition of automation Jaffe and Froomkin state: "This term should be reserved for that type of production process utilizing the automatic feedback principle, in which a control mechanism triggers an operation after taking into account what has happened before. The feedback principle generally distinguishes automation from mechanization."[26] They further state: "The ultimate in automation is the closed-loop process, a method of operation which requires no human interference from the time the raw material is inserted into the machine to the time the finished product is stored or stacked at the end of the production line."[27]

From the foregoing review of definitions it becomes obvious that there is no standardized, uniformly accepted

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[24] Ibid., pp. 618-619.

[25] Ibid., p. 121.

[26] Abram J. Jaffe and Joseph Froomkin, Technology and Jobs (New York: Frederick A. Praeger, Inc., 1968), p. 18.

[27] Ibid.

definition of automation. There does, however, appear to be wide agreement that essential to the complete automation of manufacturing and processing systems are the concepts of continuous flow and closed-loop automatic control. Partial automation can be considered then to include processes which are characterized by "islands" of automation, i.e., the entire process is not automated in an uninterrupted flow from start to finish but there are segments of the process that are automated.

The History of Automation

The German monk, Magnus, is said to have spent 30 years in building a robot which advanced to the door when someone knocked, opened it, and greeted the visitor. For his efforts, Magnus, a learned scientist, gained only a reputation as a sorcerer among his contemporaries in 13th-century Europe. The Magnus story seems a pleasant fable but, if fact and fancy had been joined, he might today be known as the "father of automation."

Actually, the beginning of automation is obscure. The ancient Chinese developed some ingenious devices including the "south-pointing chariot" and water hammers for grinding cereals. Plans for an automatic sawmill, an automatic file-cutting machine and other "automatic" devices are found in the works of 15th-century Leonardo da Vinci.

In this section the history of automation will be traced from three standpoints: (1) _the evolution of control devices_; (2) _the evolution of continuous flow of assembly and transfer operations_; and (3) _the evolution of data processing automation_. The latter is included because of the fact that electronic computers, which are, in part, the evolutionary result of office automation, are now being applied in the manufacturing process itself as control devices.

The Evolution of Automatic Control Devices

Very early examples of automatic control devices include the float control valves used in the plumbing systems of ancient Rome and another Roman water device for automatic control of temple doors. Around 1680 Denis Papin invented the pressure cooker which employed the open-loop system of control. In 1713, Humphrey Potter, then an English teenager, developed a method of controlling the flow of steam in steam engines by using a slide valve mechanism linking piston and valves. Through this linkage, steam was admitted to or exhausted from an engine cylinder automatically.[28]

There is a long history of a movement to achieve more automatic control in the textile industry. In 1725 Basil Bouchon suggested the use of punched paper tape as a means for controlling the operations of a hand loom, and three

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[28] Paul T. Veillette, "The Rise of the Concept of Automation," _Automation and Society_, _op. cit._, p. 5.

years later Falcon designed the first punched card controlled machine. In 1745 Jacques de Vaucanson adapted Falcon's machine to punched tape. It was not until the early part of the 19th century that Joseph Jacquard made practical application of these advances on a large scale. He perfected a loom controlled by punched cards. The holes in the cards contained the weaving pattern and determined needle selection. Jacquard's cards permitted diverse and intricate patterns to be produced cheaply and accurately, and, by 1812, there were 11,000 of his looms in operation in France.

The Dutch windmill was first devised during the Middle Ages, but in 1745 feedback control was added such that the sails of the windmill were kept facing into the wind by small sails placed at right angles to the large sails. Later, in 1772, a further improvement was added in the form of a spring which operated to reduce the area of sail if the wind became too strong, thus avoiding damage to the mill.[29]

A more mechanized invention employing the feedback principle was James Watt's flyball governor developed in 1788 to control the speed of steam engines. Before Watt's invention engine speed had been regulated manually by a throttle valve. By linking a flyball, or centrifugal, governor with the output shaft of the engine and also with

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[29] Andrew D. Booth, "Introduction," Progress in Automation, ed. Andrew D. Booth (London: Butterworths Scientific Publications, 1960), p. 4.

the valve that controlled steam input, it became possible to maintain constant engine speed automatically. As the engine's speed increased, the flyballs of the governor were impelled outward proportionately, decreasing the supply of steam to the engine and consequently slowing it down. Conversely, if the shaft turned too slowly, the balls collapsed inward, gradually opening the input valve. The self-regulation which was achieved represents an early example of closed-loop control.

The first application of the feedback principle to the steering of a large steamship, the Great Eastern, occurred in 1868. This was accomplished by a linkeage system between the helmsman's wheel, the throttle of the steering engine and the ship's rudder. Four years later, in 1872, Joseph Farcot, a Frenchman, coined the word "servo-motor" in naming a similar, but more advanced, ship's steering engine.[30]

The monotype, invented by Lanston in 1887, provides an example of the expanding range of applications for punched tape control. This invention used a punched tape to govern the casting and assembly of type. More recently, in 1948, a system for operating a lathe with punched tape was demonstrated.[31] An example of automatic size control was

[30] Veillette, op. cit., p. 6.

[31] "Automatic Contour Control," American Machinist (July 10, 1950), p. 75.

that developed by Bryant in 1931 for use on grinding machines.[32]

A particularly significant event in the progress of automatic control was the development of the analogue computer by Dr. Vannevar Bush during the 1930's. The design of analogue computers, and later electronic digital computers, resulted from the pressure of scientific and military demands. Analogue computers were used in World War II to direct naval and anti-aircraft guns automatically. These computers are now used in some of the liquid-products industries to control processing.

The Evolution of Continuous Flow of Assembly and Transfer Operations

Thus far this historical review has related to the evolution of automatic control. The history of automatic material handling, including assembly and transfer operations, dates back at least to 1784. At that time Oliver Evans built a "fully automatic" flour mill on the outskirts of Philadelphia. Using three basic types of conveyor mechanisms in a continuous production line, as well as controls to regulate grinding, Evans succeeded in mechanizing the entire process from raw grain to bagged flour. In addition to its automatic features, Evans' mill produced better quality flour, being cleaner and more uniform than the

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[32] "Automatic Electrical Sizing Equipment for Bryant Chucking Grinder," ibid. (April 23, 1931), pp. 664-665.

flour from conventional mills of its day.[33] This achievement is considered by some to mark the beginning of continuous transfer and assembly, with the product untouched by human hands during processing.

In 1789 Eli Whitney first manufactured the interchangeable part, a development which was a prerequisite to the automatic assembly of discrete products. In England, Marc Brunel set up a highly mechanized factory which by 1808 was producing 130,000 pulley blocks a year. Brunel's machinery system enabled ten men to produce output previously requiring 110 men.[34] By 1833 biscuit-making at the "victualling office" of the British Navy had been mechanized. The first commercial gear-cutting machine was produced in 1855.[35]

An important milestone in automatic production was Ford's moving assembly line which was originally developed during the period from 1913 to 1915. Ford's original moving assembly line operations were limited to only magneto and chassis assembly. Thus, the assembly line only partially mechanized the flow of parts and subassemblies through the plant. Furthermore, the line did not employ automatic assembly or transfer. Since then, many functions in automobile

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[33]Veillette, op. cit., p. 8.

[34]Bright, op. cit., p. 14.

[35]Booth, op. cit., p. 5.

assembly have been mechanized and efforts toward more automatic assembly and transfer have been the trend.[36]

Soon after the Ford assembly line was initiated, in 1920, the A. O. Smith Corporation completed a plant for manufacturing automobile frames automatically. The Smith plant, complete with automatic handling and assembly devices, turned out an automobile frame every eight to ten seconds. About 552 operations were performed on each frame in its 1 1/2 hour manufacturing cycle. Men were required, however, to transfer portions of the frames from one production line to another. Also, in some operations, men had to assist the machine in positioning parts accurately before actuating the production mechanism. Nonetheless, the labor content was very low.[37] A few years later the Budd Wheel Company constructed a machine for the automatic production of automobile wheels. The first truly automatic transfer machine appears to have been used in the Morris Motors plant in Coventry, England, in 1924.[38] The transfer machine unites varied operations in a single device and can move a work-piece from one station to another without human aid. In this country, in 1929, Graham-Page Motors installed a system of transfer

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[36] Bright, _op. cit._, pp. 14-15.

[37] L. R. Smith, "We Build a Plant to Run Without Men," _Magazine of Business_ (February, 1929).

[38] "Engine Blocks Completely Machined in One Multiple Tool Operation," _Automotive Industries_ (February 12, 1925), pp. 272-275.

devices in their cylinder department.[39] By 1954 two automobile manufacturers had refined product design and assembly systems to the point where the car body could be deposited in place on the chassis without human help in positioning. As of 1957 some production machines had been integrated with the conveyor system to perform the operations on each part as it moved along the assembly line. These machines, typically welders, paint sprayers and testing devices, were timed to move with the conveyor during the interval of operation and then return to their initial locations.[40]

The Evolution of Data Processing Automation

Electronic digital computers, which are partially the evolutionary result of office automation, are now being applied in the manufacturing process to effect overall control. Therefore, a brief history of the evolution of the computer seems desirable.

In 1642 the French mathematician, Blaise Pascal, invented his *Machine Arithmetique*, the first adding machine. The first genuine multiplying machine was invented by Von Leibniz in 1670. An adaptation of Pascal's adding machine, it multiplied by repeated additions, just as the electronic computer does today. The *Hermann Planimeter*, the first

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[39]"Automatic Jigs That Have Cut Automobile Costs," *Machinery* (August, 1931), pp. 897-902.

[40]Bright, *op. cit.*, p. 15.

numerical integrator, was invented in 1814.[41] Notwithstanding the early contributions of Pascal and Leibniz, it was not until about 1820 that Thomas de Colmar produced the first commercially practical office calculator, known as the Arithometer.[42] Charles Babbage, in 1833, designed the first general purpose digital computer which was termed a "difference engine." Although Babbage's computer was never built because of the technical limitations of his day, it was to be a mechanical computing machine similar in many respects to today's electronic data processing machines.[43]

Punched paper tape and punched cards, previously mentioned in the history of automatic control, have also been important in the development of office automation and the electronic computer. These media made possible intercommunication among and with office machines by providing a common language. In 1870, Jean Baudot, a French civil servant, extended developments in paper tape by perfecting the five hole column punched tape. Baudot designed the tape to serve as the common language for various models of telegraph machines. As the office equipment industry advanced, Baudot's five channel tape became the common language link among a wide variety of office machines.[44] This was a

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[41]Booth, op. cit., pp. 5-6.

[42]Veillette, op. cit., p. 10.

[43]Ibid., p. 12.

[44]Ibid., p. 11.

significant step toward integrated data processing. The first punched card accounting machines were devised by Dr. Herman Hollerith in 1886 for the purpose of processing U.S. census information.[45]

The first large scale, general purpose, truly automatic digital computer was developed at Harvard from 1937 to 1944. Known as the Mark I, this prototype of the modern digital computer was not electronic but was electromechanical in operation and contained more than 760,000 switches, relays, counter wheels, cam contacts and other parts. Because of the desirability of increased speed and greater reliability, efforts were turned almost simultaneously toward the construction of an electronic digital computer. The first one, called ENIAC (Electronic Numerical Integrator and Calculator), was built at the University of Pennsylvania between 1942 and 1946. Vastly superior to the electromechanical computer, which could perform only five to ten additions per second, the ENIAC had the capability of performing 5000 additions per second.[46] Succeeding the ENIAC has been a series of electronic computers which with each generation, have grown increasingly sophisticated. Initially applied primarily to the solution of scientific problems, electronic digital computers are now in widespread use for the efficient handling

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[45] Henry Jacobowitz, Electronic Computers (New York: Doubleday & Company, Inc., 1963), p. 93.

[46] Ibid., pp. 93-94.

of business data and are being more and more used for the control of industrial processes.

This section has traced the historical development of automatic control, automated handling and electronic computers. Bringing the picture completely up to date in these three evolutionary streams would involve an endless catalogue of automation achievements. It will be the object, however, of the next section to examine the current "state-of-the-art" in industrial automation.

The State-of-the-Art

Many authorities have agreed with the view that there is nothing basically new about automation. John Diebold says: "Automation must be viewed in proper historical perspective as a new chapter in the continuing story of man's organization and mechanization of the forces of nature."[47] Ralph Cordiner states: "it is important to recognize that 'automation' is only one phase in the process of technological progress, a natural evolutionary step in man's continuing effort to use the discoveries of science in getting the world's work done."[48] Professor Ralph C. Davis agreed with these views: "There is basically nothing new in automation. It is merely a continuation of the trend toward the transfer

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[47] Diebold, op. cit., p. 158.

[48] Ralph J. Cordiner, "Automation in the Manufacturing Industries," Automation and Society, op. cit., pp. 19-20.

of work, skill, and intelligence from man to the machine.'[49] While appearing at congressional hearings previously referred to, Dr. Cledo Brunetti of General Mills said at various times:

> First, I want to point out that automation is not a revolutionary technique, but a continuation of our progress in mechanization....
>
> Automation, a newly coined word, to describe an old, old process....
>
> Automation cannot be said to have begun on any certain date, nor can it be said that it will end at any definite time. Automation is in truth but a phase of our continuing technological advance....

Similar opinions have been voiced by many other individuals.

From the standpoint of historical perspective, then, it may be argued that there is basically nothing new about automation so far as concepts are concerned. The modern "gadgetry," which make automatic control and handling more feasible, and the extensiveness of the applications of automation are new, however. In this respect, at least, automation differs from the older concept of mechanization. Charles F. Hautau of Hautau Engineering Company reflects this view: "Since automation may be termed simply an acceleration in the industrial revolution that the world has been undergoing for the past 200 years, its newness lies in the techniques used rather than in the science itself."[50]

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[49] Ralph C. Davis, Industrial Organization and Management (New York: Harper and Brothers, 1957), p. 293.

[50] Charles F. Hautau, "Techniques and Methods of Automation," Keeping Pace with Automation, op. cit., p. 29.

Similarly Professor Edward Shils of Wharton observes: "Automation is not entirely new, but since World War II it has acquired increasing importance, primarily as a result of the development of complex control devices used by the military during the war."[51]

While the workerless plant is still a thing of the future, the fact is that we are well into the automation era. During the decade of the 1950's a surge of mechanization took place in U.S. industry. More complete mechanization was widely applied to certain functions, and by 1960 it was possible to detect definite trends in application. According to Bright the more prominent ones included:

> 1. Mechanization of more direct labor activites; in particular, the task of assembling parts.
> 2. Mechanization of material movement (material handling); including movement between machines, departments, buildings, common carriers, and in storage operations.
> 3. Mechanization of control activity; including the consolidation of controls for many machines in one control panel; program control, in which an intricate sequence of actions is directed by the control system; and feedback control, in which a high degree of self-regulation and correction is involved.
> 4. Mechanization of testing and inspection activities.[52]

Automation in Process Industries

In terms of types of industries, the "flow" concept of automation is most easily applied in the process-type

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[51] Shils, op. cit., p. 3.

[52] James R. Bright, "Skill Requirements and Wage Aspects of Automation," Industrial Relations in the 1960's. Problems and Prospects, eds. George W. Taylor and Edward B. Shils (University of Pennsylvania, 1961), Vol. I, p. 1.

industries. Among these, petroleum refining and chemical production are representative of the most susceptible to automation. Thus, in these industries, a high degree of automation has been in existence for many years (as early as the 1920's in petroleum). The distinctive characteristic of these production processes is that they operate on a continuous flow principle in which ingredients move in an uninterrupted stream as they are converted from raw materials to products. Materials, generally liquids or gases, are confined in closed pipes or tanks during the production process. Gauges, valves and other instruments must be monitored in order to measure and interpret temperatures, pressures, liquid levels, and rates within and between processes. In modern flow plants process control is accomplished by a combination of operator control and automatic control, but the direct labor content is very low. According to Shils: "About 15 percent of current capital investment in petroleum refining facilities is for automation, and the direct labor costs in oil processing are less than 10 percent of total costs.[53] In addition to the petroleum and chemical industries, there has been increasingly automatic production of materials that can be produced in a continuous sheet, strip or web, such as paper, plastics, rubber, cloth and even steel. Automation is well advanced in parts of these

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[53] Shils, op. cit., p. 13.

processes. In the flow-process industries, beyond automatic feedback instruments which turn valves, start and stop pumps and motors, etc., the trend is toward more sophisticated instrumentation with computers directing and controlling the process under minimal operator supervision.

The Automation of Discrete Production

A salient distinction in manufacturing operations focuses on the differences between production in flow processes, described above, and production of discrete units of output. The metalworking industries, for example, engage primarily in discrete production. Automation in the handling and assembling of metal parts is more difficult to accomplish than in a flow-process plant. Also the variables of process control are different and generally more numerous. However, in recent years, there have been increased efforts to apply the principles of continuous flow and automatic control to discrete production processes. The greatest progress has been made in the manufacture of simple, high volume, standardized items,[54] for example, screws and metal stampings. Beyond this, there has been a step-by-step progress toward greater automation in plants producing more complex end products.

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[54] Ralph J. Cordiner, "Automation in the Manufacturing Industries," *Automation and Society*, *op. cit.*, p. 20.

It should not be assumed that the advantages of automation are available only to large, mass-production companies. There are degrees of automation. Entire processes, parts of processes, or individual operations may be automated as conditions dictate. Automation may be complete or partial. Individual operations in which a high degree of automation now exists include material handling, packaging and inspection. In addition to the design of complete and partially automated systems, the automation industry now places much emphasis on designing flexible automation equipment which is suitable for job-lot types of operations. In many cases advances in the automation state-of-the-art are facilitated by "rethinking" or redesigning the product and the production process. This is especially the case with regard to assembly operations, perhaps the most difficult of all to automate.

Advanced automatic fabrication and control in discrete production has been achieved in many plants by uniting the information-handling capabilities of computers with production machines by means of "numerical control." For example, with numerical control, a machine tool can cut metal shapes automatically by following "programmed" instructions recorded on tape or punched card. The tape or cards are read and interpreted by the computer which controls the motion of the machine tools and the workpiece. An automatic feedback system operates to detect and correct deviations from desired

values. At the leading edge of automation in discrete production industries are efforts, where conditions warrant, to achieve complete automation of the process from beginning to end through the integration of automatic handling, automatic assembly or fabrication and automatic control. Some examples of automation applications and installations which are reported in the current literature are presented in the following paragraphs.

Automation Applications and Installations

Since its original moving assembly line was completed in 1915, the Ford Motor Company has progressively stepped-up efforts to achieve continuous automatic production. For example, Ford started operations in 1952 in a new engine plant in Cleveland. Engine blocks were produced by a battery of 71 machines linked together in an automatic line 1600 feet long. The process includes over 500 machining operations on each block. When the plant first began operations output was estimated at 154 blocks per hour, requiring 41 workers, compared to 117 workers required to produce this number of blocks by use of previous methods. Since then continued improvements have made the plant, as it was in 1952, obsolete. Bright reported that "in four research visits to the Ford Cleveland plant over an eighteen month period, the

cylinder block line never appeared the same twice. Always there were changes in machinery since the last visit."[55]

The Beloit Corporation recently completed construction of a continuous flow newsprint plant which includes an integrated control system linking all parts of the process. A computer monitors more than 200 critical points in the process and exercises direct digital control over operations throughout the process from wood grinding to finished paper reeling. The computer collects and analyzes operating data and advises the operator of unacceptable conditions. The paper making machine itself is 380 feet long and is constructed so as to provide continuous-flow production.[56]

An example of advanced automation in the process industries, specifically the petroleum industry, is ESSO's refinery near Southhampton, England. This refinery was recently presented "The Queen's Award to Industry 1969" for outstanding achievement in technological innovation. The refinery's production is directed, monitored and controlled by an "electronic watchdog system" which constitutes "the largest and most advanced use of computer control in the oil industry."[57]

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[55] Bright, Automation and Management, op. cit., p. 61.

[56] "Papermaking in Prodigious Proportions," Automation (January, 1970), pp. 84-85.

[57] "Panorama," The Lamp (New York: Standard Oil Company, New Jersey, Winter, 1969), p. 16.

Current state-of-the-art in automatic assembly is exemplified by one type of "Benerson Automator" which automatically feeds, positions and joins eight separate parts in the assembly of small electric motors. The machine produces 1000 assemblies per hour.[58] Another current automation device performs 12 automatic assembly operations including orienting, spinning, eyeletting, tapping, cut-off, placement, screwdriving and staking in the assembly of a seven part telephone component.[59]

The "Milwaukee-Matic" series of machines produced by the Kearney and Trecker Corporation provide an example of advances in numerical control. Now in their fourth generation, these numerically controlled machines are able to perform automatically a variety of operations such as cutting, reaming, tapping and boring. Capabilities include random tool selection, automatic tool changing, and automatic feedback control.[60] The "Unimate Robot" is a multipurpose handling and processing machine which can be programmed to perform up to 180 sequential operations.[61]

Obviously, the examples presented here are not exhaustive either in terms of current automation applications or in

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[58] "Electric Motors Automatically Assembled," Automation (December, 1969), p. 156.

[59] "Automatic Assembly," Automation (December, 1969), p. 7.

[60] Automation (January, 1970), pp. 76-77.

[61] Automation (December, 1969), p. 41.

terms of automated installations. They are, however, illustrative of the current state-of-the-art in industrial automation.

Manufacturing Operations Currently Automated

Further indications of the state-of-the-art in manufacturing automation are revealed by the extent to which specific manufacturing operations are currently automated. In a recent survey, conducted by the Market Research Department of *Automation*, companies in all manufacturing industries throughout the United States were asked to specify which of their operations were automated. Responses to this question were received from 2,587 establishments. The results are shown in Table I which indicates, for each operation, or group of operations, the percentage of companies automated as of 1968. Table II, based on the same study, shows the trend, from 1961 to 1968, in the use of automatic controls. For the years 1961, 1963, 1965 and 1968 responses were received from 2,713, 3,440, 3,301 and 3,752 establishments respectively. The overall survey evidences an upward trend in the application of automation equipment and techniques in manufacturing industries.

Management and Technological Evolution

The purpose of this section is to briefly trace the development of professional management in relation to technological evolution.

TABLE I

MANUFACTURING OPERATIONS AUTOMATED

Operations	% Automated
Assembly Machines	34.3
Calendering, Sheeting	5.3
Casting, Forging, Rolling	6.1
Cutting, Shearing, Forming	22.6
Filling, Closing	15.2
Finishing, Painting, Coating	17.0
Handling, Conveying, Transferring	42.5
Heating, Baking	21.8
Heat Treating	12.2
Inspection	13.5
Machine Tools	20.0
Machine Tools, Automatic Load & Unload	11.6
Machine Tools, Tape & Card Control	11.0
Mixing, Blending	21.6
Molding, Extruding	12.6
Packaging, Bundling	25.8
Plating, Polishing	7.4
Printing, Marking	17.4
Processing Machinery	27.8
Production, Inventory Control	25.2
Pumping, Proportioning	21.5
Sawing	8.5
Stamping, Drawing	14.0
Storage, Feeding, Sorting	10.9
Testing	15.2
Warehousing	8.4
Washing, Cleaning, Conditioning	14.3
Weaving, Sewing, Stitching	5.1
Weighing	23.0
Welding, Riveting, Fastening	11.5
Winding, Coiling	8.9
Special Production Lines	17.8

Source: 1968 _Automation Trends Survey and Forecast_, p. 16. (conducted by Market Research Department, _Automation_ magazine)

TABLE II

TRENDS IN AUTOMATIC CONTROL - 1961 TO 1968

	Percentage of Plants			
	1961	1963	1965	1968
Drive and speed regulation	76.4	86.9	87.2	88.2
Automatic control of sequence operations	66.2	77.9	73.2	79.2
Process sensing and control instruments	46.3	54.9	57.8	62.0
Automatic measuring and gaging	47.2	57.5	56.6	59.1
Automatic weighing	30.0	37.4	37.9	40.1
Tape or punch card control	26.9	29.6	33.8	39.1
Process analyzers	20.8	25.4	23.9	26.2
Computer control	6.0	11.6	15.1	23.1
Remote control	8.7	11.7	14.5	17.5

Source: 1968 Automation Trends Survey and Forecast, p. 11. (conducted by Market Research Department, *Automation* magazine)

The emergence and direction of management thought have been influenced by economic, social and political forces at work in the environment as well as by technological forces. For example, in enumerating what he considers the most stimulating concepts for the management movement, John Mee includes "the Protestant ethic," "Social Darwinism," and "hegel's dialectic," in addition to "technological aids to human effort."[62]

By the beginning of the nineteenth century the effects of the industrial revolution were trickling to the United States. With the rise in technological innovation came a changing managerial environment and a resulting confusion for management as well as for the workers. Old techniques and methods became obsolete. The decline of the craft system was unsettling to the skilled worker. Owners and managers were confronted with problems for which no precedents existed. They dealt with these problems largely on a trial-and-error basis. Management did not exist as a body of concepts.

The United States was still predominantly a nation of small, individual business enterprises until after the Civil War. There was not a great deal of need for, nor much interest in, formalizing management thought. The advent of

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[62] John F. Mee, Management Thought in a Dynamic Economy (New York: New York University Press, 1963), p. 15.

the factory system and large industrial organizations changed this. The size and complexity of factories led to problems that were impossible to solve without planning systematic relationships of work methods and effective organization. It was during this period--the later part of the nineteenth century--that the growth of a managerial class became apparent. Management began to change from a day-to-day, brushfire type of operation to a more all-inclusive, longer-run approach. "Improvements were begun by industrial managers and industrial engineers in methods of work and wage payments. Cost control techniques and cost accounting practices developed simultaneously with waste control and operating-efficiency methods."[63] Out of this managerial up-heaval emerged Frederick W. Taylor as the "father" of scientific management. Although Taylor's work stressed the development of standards and improved efficiency he also devised tests for placing workers and advocated higher wages to workers. He proposed a broader, more comprehensive view by management, incorporating the elements of planning, organizing and controlling.

As the United States moved into the twentieth century the industrial revolution continued, and the scientific management movement gained momentum. Its methods became more widely known and recognized, and its techniques were

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[63] Ibid., p. 24.

expanded and sharpened. The increasing size and complexity of industrial enterprise led to the growth in popularity of the corporate form of business organization. This resulted in a change in the predominant type of managers from the typical pattern of one-man management. The corporate form required a degree of multiple management to accommodate the separation of ownership and management. There evolved a new stage of management thought which concerned itself with the overall organizational problems of departmental division of work and coordination. Sometimes referred to as "administrative management theory," this new stream of management thought blended with scientific management philosophy. During the period, from about 1905 to 1930,[64] the "financial" type of manager was predominant. After the economic catastrophe of the late 1920's however, the financial managers lost public confidence and declined in influence. Subsequently, the "professional manager" emerged, and during the 1940's the conceptual framework for management developed into a "process for management." Henri Fayol first presented the concept of the "management process" in 1916. The management process, often referred to as the "functional approach," is oriented around the functions of management--planning, controlling, organizing, directing and staffing. It perceives management as the process of setting and achieving

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[64] Ibid., p. 38.

objectives or desired results by the use of people and facilitating resources.

Without elaborating on other "schools" of management thought it is sufficient to say that the tools of modern management have increased dramatically since World War II, particularly those techniques which facilitate analytical and quantitative approaches to management. Again, these developments in management have paralleled rapid technological change. Some have said we are experiencing a second industrial revolution in which automation will play an important part. In industrial firms where extensive automation takes place managers can expect a changed managerial environment.

CHAPTER III

AUTOMATION AND PLANNING

Introduction

The managerial function of planning is defined by John Mee as: "the considering and the establishing of related facts and assumptions in advance in order to design the chosen combination of actions that will result in attaining predetermined goals."[1] Elements of the planning process include policy formulation, the development of strategic plans, establishing goals and setting objectives and forecasting. Non-repetitive decision-making is also included as being central to the planning function. Mee states: "It is possible to make decisions without planning, but the thought of planning without decision-making is intolerable."[2]

It may be that planning is the managerial function most affected by automation. An observation by George Moller reflects this belief:

> ...planning is becoming the main preoccupation of top management. In fact, the faster the pace of change, the greater the need for planning for longer periods. This planning must recognize automation as the direction in which all development points, in spite of the

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[1] John F. Mee, Management Thought in a Dynamic Economy (New York: New York University Press, 1963), p. 60.

[2] Ibid., p. 61.

> fact that changes in an automated operation are more difficult to carry out than in a manual one.[3]

Similarly, Professor Julius Rezler states: "The managerial function of planning is certainly affected by automation. Because of the major technical, financial and human problems involved in automated production, its introduction requires a great deal of planning on a high managerial level well in advance."[4]

The purpose of this chapter is to discuss certain probable effects of automation on the planning function and to report, in part, the results of the survey conducted in connection with this study.

An Overview of Effects

The Criticality of Planning

Typically, the automated production line or process is a highly efficient producer of the product or products for which it was designed and usually a very unsatisfactory producer of anything else.[5] In most cases the fixed costs of installing an automated system will be high in comparison to variable costs of operations. Once committed to an

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[3] George Moller, "Will Management in Smaller Companies Keep Pace with Automation," Advanced Management Journal (April, 1964), p. 48.

[4] Julius Rezler, "Managerial Functions in the Era of Automation," ibid., p. 59.

[5] James R. Bright, Automation and Management (Norwood, Massachusetts: The Plimpton Press, 1958), p. 226.

automated line, changes in design or product became very costly. With a large fixed investment relative to variable costs, total costs cannot be appreciably reduced by cutting output. Furthermore, the labor force in an automated plant or factory is likely to consist of more salaried personnel. Thus labor costs tend to be fixed also, because salaried technicians, maintenance men, etc., must be kept on the job as long as the plant is operating, regardless of the level of output. Also, automation is most advantageous under conditions of stable, continuous output. Therefore, even material costs may tend to be relatively fixed due to the necessity of long-term commitments for materials in order to ensure a continuous supply. The combined result of all these factors is that the completely automatic plant is relatively inflexible as to product and volume. This means that the function of planning, particularly long-range planning, becomes much more critical in the overall management process. The difference between a relatively high degree of flexibility in a conventional plant and the inflexibility of an automated plant demands extremely competent, realistic and sound advance planning.

Expanded Planning Horizon

Automation is characterized by the interdependency and the integration of the various elements of the production system. The flexibility of individual, multi-purpose,

relatively moveable machines that can be shifted around and adapted to another product is not present. Consequently, the need for careful system design is much greater in the automated plant, production line, or subsystem. This requires that management expand its planning horizon. Since changes are usually so costly once a process is automated, it is necessary to anticipate required changes and design the system to accommodate them with minimum difficulty. Furthermore, a commitment to automate has to be accompanied by very careful planning and analysis with regard to such factors as product demand, technological obsolescence and life of the production system.

Herbert Simon has predicted an expansion of management's time perspective:

> ....in future years the manager's time perspective will be lengthened. As automated subsystems take over the minute-by-minute and day-by-day operation of the factory and office, the humans in the system will become increasingly occupied with preventive maintenance, with system breakdowns and malfunctions, and--perhaps most important of all--with the design and modification of systems .... the company executives will be much more concerned with tomorrow's automatic factory.[6]

Effect of Integration on Management Philosophy

The integrated and interdependent nature of automation means such a basic change in production that management philosophy is likely to be affected in a way that amounts

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[6] Herbert A. Simon, The Shape of Automation for Men and Management (New York: Harper & Row, 1965), pp. 47-48.

to an expanded view of the enterprise. Under mechanization, production is organized around the traditional division of labor and the subdivision of functions. Automation involves a movement away from the division of labor. Instead it requires that the production process be viewed as a complete, integrated system from introduction of raw material to completion of the final product or subassembly.

The Importance of Forecasting

While various types of business forecasting activities are highly desirable in conventional manufacturing enterprises, the forecasting element of managerial planning becomes even more necessary in automated plants. The marketing of a high volume of generally standardized product coming off an automated production line has to be planned. Greater emphasis is therefore likely to be placed on sales forecasting which must be wedded to production forecasts. The requirement for increased numbers of skilled technicians to man the automated facility suggests more rigorous manpower forecasting. Likewise, the high fixed cost of automated systems and subsequent changes indicates a need for longer-range financial and profit forecasting. It is therefore postulated that forecasting encompasses a greater range of activities in the automated firm; that forecasts are made more frequently; and that they tend to cover longer periods of time.

Effects on the Decision Environment

The integrated, complete-system features of automation magnify the consequences of error. In a manual plant material shortages, an inoperative machine, and poor production scheduling might have only a slight cumulative effect. On an automated line these conditions might halt production altogether. Because of the seriousness of ill-considered actions, compressed decision time-frames, and the number of decisions to be made an automated system puts added pressure on the decision process. This suggests that managers of automated facilities must rely increasingly on systematic and analytic aids to decision making. A statement by Drucker seems particularly appropriate:

> In dealing with their new tasks, the managers of the 1960's will, to a large extent, have to employ the same tools they are using today. But managers will also find, increasingly, that they are expected to know, understand, and handle new concepts and tools of management. Increasingly, they will find that they are expected to use systematic methods of analysis and decision-making, supplemented by new systematic tools of communications, computation and presentation.
>
> Executives can safely disregard all the fanciful talk about the computer replacing managers and making decisions. Managers' work, it can be said with confidence, is going to be more important, and their numbers larger. But the management sciences--such as operations research or decision-making logic--and the new electronic tools and systems are going to make a difference, even to the manager of the small business.
>
> And the manager of 1970 will need all the help he can get from such new concepts and tools. For his job is going to be so complex, so big, so demanding

> as to require all the tools of simplification and systematization that can be possibly obtained.[7]

Survey Results: Planning

It is perhaps desirable to first review briefly some of the information concerning the survey of companies which was described under Research Methodology in Chapter I. Of the 990 companies to which questionnaires were sent, 247 companies responded with useful information prior to the cut-off date. Thus a useful response rate of 24.9 per cent was experienced. Categorizing these 247 companies by "automated" and "not automated" production processes resulted in 131 companies (53 per cent) falling in the automated group and 116 companies (47 per cent) in the non-automated group. Questions 3, 4, 5, and 6 of the questionnaire were designed to determine the effects of automation on certain aspects of managerial planning. For purposes of tabulating and analyzing responses, Questions 3 and 4 were subdivided into 3a, 3b, 4a and 4b.

Evidence of Written Corporate Plans

It was felt that at least one indication of the relative necessity for formalized planning experienced by management could be obtained by determining the extent to which the

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[7] Peter F. Drucker, "The Next Decade in Management," *Dun's Review and Modern Industry* (December, 1959), pp. 60-61.

companies had drawn up written corporate plans. Fayol states "Planning is manifested on a variety of occasions and in a variety of ways, its chief manifestation, apparent sign and most effective instrument being the plan of action."[8] The existence of a written plan of action provides evidence of and is one measure of how important and how critical planning is for management in a given company. Thus Question 3a was asked as follows: "Does your company have a written corporate plan?" In response to this question 101 companies (77 per cent) in the automated group of 131 companies answered "yes," and 30 companies (23 per cent) answered "no." In the non-automated group of 116 companies, 36 (31 per cent) answered "yes," and 80 (69 per cent) answered "no." In analyzing these results three statistical tests were applied: the Chi Square test for independence; the test for difference in proportions; and estimation of the population proportion within a confidence interval.

The Chi Square test with "two-way classification" was applied to test the hypothesis that the two characteristics, "type of production process" and "existence of a written corporate plan," are independent. If they are independent "the distribution of one characteristic should be the same

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[8]Henri Fayol, General and Industrial Administration (New York: Pitman Publishing Corporation, 1949), p. 43.

regardless of the other characteristic."[9] For example, if the two characteristics are independent then the proportion of companies with written plans having automated production should be the same as the proportion of companies without written plans having automated production. The observed value of Chi Square was computed to be 52.85 which is much larger than any critical value of Chi Square for one degree of freedom.[10] For example, the value of Chi Square with one degree of freedom at the .5 per cent (.005) level of significance is 7.88.[11] The observed value of 52.85 lies in the "critical region" which calls for rejecting the hypothesis of independence. Also, using a null hypothesis that automation does not have any effect on firms having written corporate plans, a comparison of the observed value of Chi Square with the critical value of 7.88 results in rejection of the null hypothesis.

Using the observed response proportions of 77 per cent of the automated companies having corporate plans and 31 per cent of the non-automated companies having corporate plans, the test for difference in proportions was used to test the

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[9] Wilfrid J. Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis (New York: McGraw-Hill Book Company, Inc., 1957), p. 224.

[10] The appropriate number of degrees of freedom is obtained by multiplying (the number of rows minus 1) times (the number of columns minus 1). The matrix here is "two by two" which gives one degree of freedom.

[11] Ibid., Table A-6a, p. 385.

hypothesis that the two population proportions having written plans are equal. The test results indicated that the difference in population proportions was significant at the 1 per cent (.01) level. Based on this result the hypothesis that the two population proportions are equal would be rejected.

Considering only the responses of companies in the automated group, estimates of the automated population proportion having written corporate plans were computed using 95 per cent and 99 per cent confidence limits. The 95 per cent confidence limits were .698 and .842, and the 99 per cent confidence limits were .675 and .865. Therefore, based on the survey data, it can be said with 95 per cent confidence that the proportion of automated companies having written corporate plans lies between .698 and .842. With 99 per cent confidence, it can be said that the proportion lies between .675 and .865.

Estimates of the non-automated population proportion having written corporate plans were also computed by determining the limits for 95 per cent and 99 per cent confidence. The resulting intervals were .226 to .394 and .199 to .421 respectively.

While there are very likely other causal factors (particularly company size which was discussed in Chapter I) which enter into whether or not companies have written corporate plans, the survey data from Question 3a support the hypothesis that the management of automated companies does

experience a more critical need for planning as reflected by the existence of written corporate plans.

Comparison of Planning Periods

If a respondent answered "yes" to Question 3a he was then asked in Question 3b to answer: "what future time period or periods does your plan include--i.e. 1 yr., 5 yr., 1 yr. and 5 yr., etc.?" The purpose of this question was to provide for a comparison of the automated and non-automated groups of companies in terms of the length of planning periods. Of course, the comparison is only between the 101 companies in the automated group and the 36 companies in the non-automated group which indicated that they have written plans.

The responses were first tabulated exactly as each company answered the question. The results of this tabulation are presented in Table III. The major difference between the two groups shown by the figures in Table III is that 45.55 per cent of the automated companies have one year and five year plans whereas for the non-automated group this figure is 36.11 per cent. Also, only 7.92 per cent of the automated group have corporate plans covering only a period of one year. On a percentage basis, approximately twice as many (16.67 per cent) in the non-automated group engage in one year planning only.

Further analysis of Table III shows that 56 companies (55.4 per cent) in the automated group have multiple year

plans. In the non-automated group 16 companies (44.4 per cent) indicated that they prepare multi-year plans. Using these percentages, the test for difference in population proportions was made. The test results indicated that there is not a significant difference in the automated and non-automated population proportions having multiple year plans. The test was made at the 5 per cent (.05) level of significance. It is repeated that the populations referred to here and reflected in Table III are not "automated companies" and "non-automated companies" but "automated companies having written plans" and "non-automated companies having written plans." Therefore, what the survey response indicates is that for companies which have written plans covering any period there is not a significant difference, with regard to multiple year planning, between the automated group and the non-automated group.

A rearrangement of the information in Table III provides for easier comparison of the automated and non-automated groups in terms of the number and percentages of companies which have plans covering specified periods of time. The rearranged information is shown in Table IV. An individual company may be included in several planning periods. The cumulative percentages are therefore greater than 100 per cent. A major question in which the investigator was interested was whether or not the survey data indicated that automated companies tend to engage in longer-range planning

TABLE III

COMPARISON OF PLANNING PERIODS BASED ON NUMBERS OF RESPONDENTS HAVING WRITTEN PLANS

Periods	Automated (101)		Non-automated (36)	
	Number	Per cent	Number	Per cent
1 yr. only	8	7.92	6	16.67
3 yr. only	4	3.96	3	8.33
1 yr. & 3 yr.	3	2.97	0	0.00
1 yr. & 4 yr.	1	0.99	0	0.00
1 yr. through 4 yr.	1	0.99	0	0.00
5 yr. only	33	32.67	11	30.55
1 yr. & 5 yr.	46	45.55	13	36.11
2 yr. & 5 yr.	1	0.99	0	0.00
1 yr., 3 yr., & 5 yr.	0	0.00	1	2.78
1 yr. through 3 yr., and 5 yr.	0	0.00	1	2.78
1 yr. through 5 yr.	3	2.97	0	0.00
3 yr. & 10 yr.	0	0.00	1	2.78
1 yr. through 5 yr., and 10 yr.	1	0.99	0	0.00

TABLE IV

COMPARISON OF THE AUTOMATED AND NON-AUTOMATED GROUPS HAVING WRITTEN PLANS BY SPECIFIED PLANNING PERIODS

Period	Automated (101)		Non-automated (36)	
	Number	Per cent	Number	Per cent
1 year	63	62.38	21	58.33
2 years	6	5.94	1	2.78
3 years	12	11.88	6	16.67
4 years	6	5.94	0	0.00
5 years	84	83.17	26	72.22
10 years	1	0.99	1	2.78

than do non-automated companies. For example, Table [illegible] shows that 83.17 per cent of the automated group (having written plans) have five year plans. The corresponding figure for the non-automated group is 72.22 per cent. Based on the test for difference in population proportions[12] it was concluded that there is not a significant difference between the two groups with regard to having five year plans.

It can be concluded then from an analysis of Tables III and IV that, considering only companies which <u>do</u> have written corporate plans, there do not appear to be significant differences between the automated and non-automated companies with regard to the amount of multi-year planning and the extent of longer-range planning.

To enable a comparison of planning periods based on the total number of respondents in each group (instead of just the numbers of respondents having written plans), Tables V and VI were compiled. The percentages shown in Tables V and VI for the non-automated group are generally much less than those for the automated group. The lower percentages for the non-automated group result from the relatively large number of non-automated companies which do not have written plans at all.

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[12]Computed for both the 5 per cent (.05) and 10 per cent (.10) levels of significance.

TABLE V

COMPARISON OF PLANNING PERIODS BASED ON TOTAL NUMBERS OF RESPONDENTS IN THE AUTOMATED AND NON-AUTOMATED GROUPS

Periods	Automated (131)		Non-automated (116)	
	Number	Per cent	Number	Per cent
No written plan	30	22.90	80	68.97
1 yr. only	8	6.11	6	5.17
3 yr. only	4	3.05	3	2.59
1 yr. & 3 yr.	3	2.29	0	0.00
1 yr. & 4 yr.	1	0.76	0	0.00
1 yr. through 4 yr.	1	0.76	0	0.00
5 yr. only	33	25.19	11	9.48
1 yr. & 5 yr.	46	35.11	13	11.21
2 yr. & 5 yr.	1	0.76	0	0.00
1 yr., 3 yr., & 5 yr.	0	0.00	1	0.86
1 yr. through 3 yr., and 5 yr.	0	0.00	1	0.86
1 yr. through 5 yr.	3	2.29	0	0.00
3 yr. & 10 yr.	0	0.00	1	0.86
1 yr. through 5 yr., and 10 yr.	1	0.76	0	0.00

TABLE VI

COMPARISON BY SPECIFIED PLANNING PERIODS BASED ON TOTAL NUMBERS OF RESPONDENTS IN THE AUTOMATED AND NON-AUTOMATED GROUPS

Period	Automated (131)		Non-automated (116)	
	Number	Per cent	Number	Per cent
No written plan	30	22.90	80	68.97
1 year	63	48.09	21	18.10
2 years	6	4.58	1	0.86
3 years	12	9.16	6	5.17
4 years	6	4.58	0	0.00
5 years	84	64.12	26	22.41
10 years	1	0.76	1	0.86

Evidence of Written Objectives and Goals

In an article entitled "The Essential Nature of Objectives" John Mee states:

> ... The entire management process concerns itself with ways and means to realize predetermined results.... Objectives may be general or specific; they may concern the organization as a whole, a segment of it within a decentralized unit, or even a particular function such as production, sales, or personnel.... Unless predetermined objectives are set and accepted, little or no basis exists for measuring the success and effectiveness of those who perform the management functions.[13]

With regard to setting objectives and goals in the automated production environment Bright observes:

> ...No longer can management simply "run" the plant to make whatever is selling. Now, management must decide well in advance exactly what it wants to make, how much it wants to make, at what rate it is to be made, and over what period....Therefore, an extremely careful planning job, which means laying down a clear set of requirements of input, output, and operating characteristics for the supermachine, must be done.[14]

In conducting the survey, it was felt that the existence of written statements of objectives and goals would be another indication of the importance of advance planning for management. In order to obtain data for a comparison of the automated and non-automated groups of companies Question 4a was asked: "Does your company have a written statement of objectives and goals?" In response to this question 80 companies (61 per cent) in the automated group of 131

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[13]John F. Mee, "The Essential Nature of Objectives," Management: A Book of Readings, eds. Harold Koontz and Cyril O'Donnell (New York: McGraw-Hill, Inc., 1968), pp. 53-54.

[14]Bright, op. cit., p. 231.

companies answered "yes," and 51 companies (39 per cent) answered "no." Of the non-automated group of 116 companies, 28 (24 per cent) responded "yes," and 88 (76 per cent) said "no." These results were analyzed by use of the Chi Square test, the test for difference in proportions, and an estimation of the population proportions within confidence intervals.

The observed value of Chi Square obtained through computation was 34.10. When compared with the critical value of Chi Square with one degree of freedom at the .5 per cent (.005) level of significance,[15] the observed value calls for rejection of the hypothesis that the two characteristics "type of production process" and "existence of written statement of objectives and goals" are independent. Also, the observed value of Chi Square does not support the null hypothesis that automation has no effect on firms having written objectives and goals.

The observed response proportions of 61 per cent of the automated group of companies and 24 per cent of the non-automated group having written objectives and goals, respectively, were used to test for difference in the two population proportions. The test results indicated that, based on the survey data, there is a significant difference in the population proportions at the 1 per cent (.01) level.

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[15]This value of Chi Square is 7.88.

Confidence limit estimates of the population proportions having written statements of objectives and goals were computed for both the automated and non-automated populations. The 95 and 99 per cent confidence limits for the automated population were .5265 & .6935 and .5003 & .7197 respectively. The corresponding confidence limits for the non-automated population were .1622 & .3178 and .1377 & .3423.

The statistical results obtained from the response to Question 4a were similar to those for Question 3a and indicate a greater importance attached to advance planning by management in automated companies as reflected by the existence of written statements of objectives and goals.

Response to Request for Company Objectives

If a company responded affirmatively to Question 4a it was then asked in Question 4b: "Would you please enclose a copy of your statement of objectives." This question was asked because of an interest in determining if there appeared to be differences (primarily qualitative) between automated and non-automated companies in the nature of their objectives.

There was great reluctance on the part of the respondents to provide copies of their objectives. This was true for both the automated and the non-automated groups. Of the 80 companies in the automated group indicating that they have written statements of objectives only 12 companies (15 per

cent) actually provided copies with their returned questionnaires. Out of the 28 non-automated companies having written objectives only 4 companies (14.3 per cent) forwarded copies. Many companies stated that a copy of their objectives could not be provided because of their "confidential" nature or that their objectives are "not for outside viewing." Because of the poor response to this question it was not possible to make a comparison of automated and non-automated companies objectives. For illustrative purposes the first stated objective of several of the companies that did provide copies were excerpted and are quoted below.

Automated Group:

> Company A--The single, overriding objective of the management of (Company A), over an indefinite period, is to optimize the return from the resources entrusted to it, consistent with the best interests of customers, employees, stockholders and community.
>
> Company B--To develop earnings per share that can be sustained over the long range and can be increased progressively without erratic swings during various cyclical periods.
>
> Company C--To make a profit by serving primarily the (   ) industries through engineering, manufacture and marketing of high-quality products.
>
> Company D--To contribute toward a better life for our employees and their families.
>
> Company E--To build an integrated technology company.
>
> Company F--To manage our business with the primary objective of making a contribution to society.

Non-automated Group:

> Company G--...to carefully plan, organize, coordinate, and control its available resources of time, space,

> material, money and people to insure their most productive and effective use.
>
> Company H--To accept and fulfill its responsibilities in perpetuating the private enterprise system, recognizing that it is this system of government which has given it this opportunity in the first place.
>
> Company I--People - To provide an environment for growth, dignity, achievement, satisfaction and equal opportunity for all employees. Return - To achieve a rate of return on net worth of 15% after taxes, to assume above average risk to achieve this above average return... Achievement of this return in the short run should not be at the expense of long range progress in such areas as research and development, manufacturing research and advertising. Incentives - To continue the present policy of paying a year end profit sharing bonus.

Also of particular interest are the statements of several of the companies concerning their objectives with regard to manufacturing technology.

Automated Group:

> Company A--...to aggressively pursue mechanized processes from the design, engineering and manufacturing levels, particularly with respect to parts and product standardization....to integrate all production operations wherever economically and technically feasible.
>
> Company B--...entry into related new markets and products based upon...existing or newly developed technology.

Non-automated Group:

> Company C--We will organize to innovate in the forming, machining, and assembly of our product.

Examples of the complete statements of company objectives are presented in Appendices C and D for the automated and the non-automated groups respectively. Individual companies have been disguised for reasons of propriety.

Comparison of Forecasting Practices

Forecasting is considered a part of the overall planning process. In practice, however, planning and forecasting are different aspects of the same process. As Stewart Thompson puts it:

> The contribution of the business planner is this: Despite the impossibility of accurately forecasting the future, he identifies a range of possibilities and prepares for them. Once this is understood, the difference between planning and forecasting becomes clearer. "Forecasting" is the attempt to find the most probable course of events or a range of probabilities. "Planning" is deciding what one will do about them.[16]

The purpose of Question 5 of the questionnaire was to obtain information enabling a comparison of automated and non-automated companies with regard to various forecasting activities--specifically sales, production, profit, manpower, financial, equipment, facility or plant, and technological forecasting. With the exception of technological forecasting all of these forecasting applications have long been recognized as useful to management. Technological forecasting, as a formally recognized management tool, is relatively new. A recognized expert on technological forecasting, Raymond S. Isenson states:

> Technological forecasting may be defined in two ways. The first can be thought of as an attempt to predict a technological application, such as stating: "In 1972, the United States will fly the prototype of the supersonic transport." The second attempts to forecast some potential, such as: "In the year 2000, physicists will have the knowledge and techniques to

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[16]Stewart Thompson, "What Planning Involves," Management: A Book of Readings, op. cit., p. 44.

> harness the fusion of hydrogen." In either case, the purpose of technological forecasting is to provide a tool for management, an input to the planning process of a corporate or governmental decision maker....Compared with the current level of interest, activities in this area prior to 1960 may almost be discounted as random happenings. Since 1960, management interest in explicit technological forecasting has grown at an astonishing rate.[17]

Question 5 was designed to determine the relative extent of forecasting activities, to compare the frequency with which forecasts are made, and to compare the periods for which these forecasts are made. The question reads as follows: "Indicate by check-marks which of the following types of forecasting activities your company engages in; also please indicate how often forecasts are made and the length of the forecasts." Below the question, a format was prescribed with spaces for the respondents to indicate their answers. The complete question reads as shown in Chapter I.

Table VII is a summary of the respondents' answers concerning the types of forecasts which they make. The table shows the number and percentage of companies of each of the two groups, automated and non-automated, which indicated that they forecast in each of the specified areas. The results of the statistical analysis of the data contained in Table VII are presented in Table VIII. All of the observed Chi Square values are greater than the critical value of Chi Square of 7.88 given for one degree of freedom at the .5 per

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[17]Raymond S. Isenson, "Technological Forecasting: A Management Tool," ibid., p. 85.

cent (.005) level of significance. The observed values of Chi Square, based on the survey responses, indicate that automation does have an effect on whether or not companies engage in forecasting in each of the specified areas. Also for each of the specified forecasting areas, the difference in population proportions is significant at the 1 per cent (.01) level. Estimates of the population proportions using 95 per cent confidence limits are also presented in Table VIII for each of the forecasting areas.

TABLE VII

COMPARISON OF FORECASTING IN THE AUTOMATED AND NON-AUTOMATED GROUPS BY TYPE OF FORECAST

Type of Forecast	Automated (131)		Non-automated (116)	
	Number	Per cent	Number	Per cent
A. Sales forecasts	128	97.71	97	83.62
B. Production forecasts	121	92.37	84	72.41
C. Profit forecasts	126	96.18	82	70.69
D. Manpower forecasts	98	74.81	42	36.21
E. Financial requirements	118	90.08	76	65.52
F. Equipment requirements	114	87.02	70	60.35
G. Facility or plant requirements	110	83.97	50	43.10
H. Technological forecasts	53	40.46	11	9.48
I. Other	11	8.40	4	3.45

TABLE VIII

ANALYSIS OF FORECASTING ACTIVITY

Type of Forecast	Chi Square	Diff. in Population Proportions-Level of Significance	Estimates of Population Proportions by 95% Confidence Limits	
			Automated	Non-automated
A. Sales	15.06	.01	.952 & 1.000	.709 & .903
B. Production	17.38	.01	.879 & .969	.643 & .805
C. Profit	30.06	.01	.929 & .995	.624 & .790
D. Manpower	37.34	.01	.674 & .822	.275 & .449
E. Financial	21.99	.01	.850 & .952	.568 & .742
F. Equipment	31.92	.01	.812 & .928	.514 & .692
G. Facility or plant	45.03	.01	.777 & .903	.341 & .521
H. Technological	30.74	.01	.321 & .489	.042 & .148

Tables IX through XVI contain the summarized tabulations of the companies responses to "how often" forecasts are made. Each of the tables contains the data for one of the specified forecasting areas -- "Sales," "Production," "Profit," etc. The group sizes shown in parentheses are the numbers of respondents which indicated that they make forecasts of the specified type. For example, Table IX shows a comparison of the frequency of forecasts between the 128 automated companies and the 97 non-automated companies which make sales forecasts. The percentages shown are based on these group sizes and not on the total group sizes of 131 automated companies and 116 non-automated companies. An analysis of the tables shows that for sales, production and profit forecasting (Tables IX, X and XI) the percentages for monthly and quarterly forecasts are higher in the automated group, and the percentages for semi-annual and annual forecasts are lower in the automated group. Table XII indicates more frequent manpower forecasting by the non-automated group. Table XIII shows higher percentages of monthly and quarterly financial forecasts for the automated group, roughly equal percentages for semi-annual forecasts and a lower percentage for annual forecasts in the automated group. With regard to equipment, facility and technological forecasting, Tables XIV, XV and XVI, respectively, reflect more frequent forecasts by the automated group. The soundness of a comparison based on Table XVI is doubted because of the

small number of non-automated companies engaging in technological forecasting. The overall analysis of Tables IX through XVI indicates that, with the exception of manpower forecasts, the automated groups perform forecasts more frequently than the non-automated groups.

TABLE IX

SALES FORECASTING: COMPARISON OF FREQUENCY OF FORECASTS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

How Often	Automated (128)		Non-automated (97)	
	Number	Per cent	Number	Per cent
L. T. Monthly	3	2.34	3	3.09
Monthly	35	27.34	20	20.62
Quarterly	39	30.47	19	19.59
Semi-annually	14	10.94	12	12.37
Annually	55	42.97	45	46.39
G. T. Annually	1	0.78	0	0.00
Periodically	1	0.78	1	1.03

TABLE X

PRODUCTION FORECASTING: COMPARISON OF FREQUENCY OF FORECASTS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

How Often	Automated (121)		Non-automated (84)	
	Number	Per cent	Number	Per cent
L. T. Monthly	8	6.61	9	10.71
Monthly	51	42.15	26	30.95
Quarterly	30	24.79	15	17.86
Semi-annually	6	4.96	8	9.52
Annually	34	28.10	28	33.33
G. T. Annually	0	0.00	0	0.00
Periodically	2	1.65	0	0.00

TABLE XI

PROFIT FORECASTING: COMPARISON OF FREQUENCY OF FORECASTS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

How Often	Automated (126)		Non-automated (82)	
	Number	Per cent	Number	Per cent
L. T. Monthly	1	0.79	1	1.22
Monthly	34	26.98	15	18.29
Quarterly	37	29.37	15	18.29
Semi-annually	15	11.90	10	12.20
Annually	54	42.86	43	52.44
G. T. Annually	1	0.79	0	0.00
Periodically	2	1.59	1	1.22

TABLE XII

MANPOWER FORECASTING: COMPARISON OF FREQUENCY OF FORECASTS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

How Often	Automated (98)		Non-automated (42)	
	Number	Per cent	Number	Per cent
L. T. Monthly	5	5.10	8	19.05
Monthly	18	18.37	6	14.29
Quarterly	20	20.41	9	21.43
Semi-annually	11	11.22	2	4.76
Annually	40	40.82	17	40.48
G. T. Annually	1	1.02	0	0.00
Periodically	7	7.14	0	0.00

TABLE XIII

FINANCIAL FORECASTING: COMPARISON OF FREQUENCY OF FORECASTS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

How Often	Automated (118)		Non-automated (76)	
	Number	Per cent	Number	Per cent
L. T. Monthly	3	2.54	6	7.89
Monthly	30	25.42	15	19.74
Quarterly	36	30.51	13	17.11
Semi-annually	9	7.63	5	6.58
Annually	49	41.53	35	46.05
G. T. Annually	2	1.69	0	0.00
Periodically	3	2.54	4	5.26

TABLE XIV

EQUIPMENT FORECASTING: COMPARISON OF FREQUENCY OF FORECASTS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

How Often	Automated (114)		Non-automated (70)	
	Number	Per cent	Number	Per cent
L. T. Monthly	0	0.00	0	0.00
Monthly	4	3.51	3	4.29
Quarterly	17	14.91	5	7.14
Semi-annually	12	10.53	5	7.14
Annually	73	64.04	50	71.43
G. T. Annually	3	2.63	0	0.00
Periodically	7	6.14	7	10.00

TABLE XV

FACILITY OR PLANT FORECASTING: COMPARISON OF FREQUENCY OF FORECASTS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

How Often	Automated (110)		Non-automated (50)	
	Number	Per cent	Number	Per cent
L. T. Monthly	0	0.00	0	0.00
Monthly	4	3.64	1	2.00
Quarterly	11	10.00	3	6.00
Semi-annually	9	8.18	1	2.00
Annually	75	68.18	40	80.00
G. T. Annually	3	2.73	1	2.00
Periodically	10	9.09	5	10.00

TABLE XVI

TECHNOLOGICAL FORECASTING: COMPARISON OF FREQUENCY OF FORECASTS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

How Often	Automated (53)		Non-automated (11)	
	Number	Per cent	Number	Per cent
L. T. Monthly	0	0.00	0	0.00
Monthly	2	3.77	0	0.00
Quarterly	4	7.55	0	0.00
Semi-annually	3	5.66	0	0.00
Annually	30	56.60	9	81.82
G. T. Annually	3	5.66	0	0.00
Periodically	11	20.75	2	18.18

Comparisons of the time periods for which forecasts are made are presented in Tables XVII through XXIV. As in the analysis of forecast frequency, each table contains the survey results for one of the specified forecasting areas, and the percentages given are based on the group sizes shown in parentheses which are the numbers of respondents indicating that they make forecasts of the specified type. Tables XVII, XVIII and XIX show that for sales, production and profit forecasting, respectively, there are generally only small differences between the automated and non-automated groups in the percentages of companies forecasting for various future time periods, except for the five year period. The five year percentages in these three tables are considerably higher for the automated group than for the non-automated

group. In Tables XX and XXI, covering manpower and financial forecasting periods, the percentages of non-automated companies are higher for very short-run forecasts of less than a month or one month. These two tables also show considerably higher percentages of the automated group making five year forecasts. In Table XXII on equipment forecasting, the only sizeable difference is in the five year forecast category. The automated group percentage is higher than that for the non-automated group. The major differences in facility or plant forecast periods reflected in Table XXIII are for the one year and five year periods. The non-automated percentage is higher for one year forecasts and, again, the automated percentage is higher for five year forecasts. A comparison by technological forecast periods shown in Table XXIV is of doubtful use because of the small number of non-automated companies making such forecasts. Thus for sales, production, profit, manpower, financial, equipment and facility forecasting the survey response indicates that the automated group tends to forecast for longer time periods (based on comparisons of the five year percentages). Statistical analysis by testing for the difference in population proportions, using the five year percentages, resulted in: differences for sales, profit and financial forecasting significant at the 1 per cent (.01) level; a difference for production forecasting significant at the 5 per cent (.05) level; and a difference for equipment forecasting significant at the 10

per cent (.10) level. Differences in population proportions for manpower and facility forecasting were found to be "not significant."

There were only a small number of companies in both the automated and non-automated groups which indicated "other" types of forecasting activities. Examples of responses from the automated group are "general economic forecasting," "raw material availability," and "marketing costs." Responses from the non-automated group include "raw material requirements" and "share of the market."

TABLE XVII

SALES FORECASTING: COMPARISON OF FORECAST PERIODS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

Length of Forecast	Automated (128)		Non-automated (97)	
	Number	Per cent	Number	Per cent
L. T. a month	1	0.78	0	0.00
One month	10	7.81	4	4.12
Two months	0	0.00	1	1.03
Three months	17	13.28	13	13.40
Four months	2	1.56	0	0.00
Six months	12	9.38	11	11.34
One year	81	63.28	63	64.95
One-and-a-half years	3	2.34	3	3.09
Two years	5	3.91	3	3.09
Three years	7	5.47	3	3.09
Four years	3	2.34	1	1.03
Five years	39	30.47	11	11.34
Ten years	2	1.56	0	0.00
Variable	0	0.00	1	1.03

TABLE XVIII

PRODUCTION FORECASTING: COMPARISON OF FORECAST PERIODS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

Length of Forecast	Automated (121)		Non-automated (84)	
	Number	Per cent	Number	Per cent
L. T. a month	2	1.65	3	3.57
One month	17	14.05	9	10.71
Two months	0	0.00	3	3.57
Three months	22	18.18	14	16.67
Four months	2	1.65	0	0.00
Six months	11	9.09	12	14.29
One year	64	52.89	40	47.62
One-and-a-half years	3	2.48	3	3.57
Two years	3	2.48	2	2.38
Three years	1	0.83	2	2.38
Four years	2	1.65	1	1.19
Five years	17	14.05	5	5.95
Ten years	1	0.83	0	0.00
Variable	1	0.83	0	0.00

TABLE XIV

PROFIT FORECASTING: COMPARISON OF FORECAST PERIODS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

Length of Forecast	Automated (126)		Non-automated (82)	
	Number	Per cent	Number	Per cent
L. T. a month	0	0.00	0	0.00
One month	9	7.14	5	6.10
Two months	0	0.00	1	1.22
Three months	16	12.70	11	13.41
Four months	3	2.38	0	0.00
Six months	5	3.97	6	7.32
One year	84	66.67	53	64.63
One-and-a-half years	1	0.79	1	1.22
Two years	3	2.38	2	2.44
Three years	5	3.97	6	7.32
Four years	3	2.38	1	1.22
Five years	33	26.19	5	6.10
Ten years	1	0.79	0	0.00
Variable	1	0.79	1	1.22

TABLE XX

MANPOWER FORECASTING: COMPARISON OF FORECAST PERIODS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

Length of Forecast	Automated (98)		Non-automated (42)	
	Number	Per cent	Number	Per cent
L. T. a month	2	2.04	5	11.90
One month	1	1.02	4	9.52
Two months	0	0.00	0	0.00
Three months	12	12.24	4	9.52
Four months	2	2.04	0	0.00
Six months	11	11.22	2	4.76
One year	44	44.90	20	47.62
One-and-a-half years	0	0.00	1	2.38
Two years	3	3.06	2	4.76
Three years	4	4.08	3	7.14
Four years	4	4.08	1	2.38
Five years	20	20.41	5	11.90
Ten years	1	1.02	0	0.00
Variable	6	6.12	1	2.38

TABLE XXI

FINANCIAL FORECASTING: COMPARISON OF FORECAST PERIODS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

Length of Forecast	Automated (118)		Non-automated (76)	
	Number	Per cent	Number	Per cent
L. T. a month	1	0.85	3	3.95
One month	5	4.24	9	11.84
Two months	1	0.85	0	0.00
Three months	16	13.56	5	6.58
Four months	3	2.54	0	0.00
Six months	11	9.32	5	6.58
One year	62	52.54	40	52.63
One-and-a-half years	2	1.69	1	1.32
Two years	7	5.93	2	2.63
Three years	8	6.78	10	13.16
Four years	4	3.39	1	1.32
Five years	30	25.42	7	9.21
Ten years	1	0.85	0	0.00
Variable	2	1.69	4	5.26

TABLE XXII

EQUIPMENT FORECASTING — COMPARISON OF FORECAST PERIODS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

Length of Forecast	Automated (114)		Non-automated (70)	
	Number	Per cent	Number	Per cent
L. T. a month	0	0.00	0	0.00
One month	0	0.00	1	1.43
Two months	0	0.00	0	0.00
Three months	4	3.51	0	0.00
Four months	1	0.88	0	0.00
Six months	4	3.51	6	8.57
One year	65	57.02	41	58.57
One-and-a-half years	2	1.75	1	1.43
Two years	9	7.89	4	5.71
Three years	9	7.89	7	10.00
Four years	4	3.51	1	1.43
Five years	27	23.68	9	12.86
Ten years	1	0.88	0	0.00
Variable	5	4.39	7	10.00

TABLE XXIII

FACILITY OF PLANT FORECASTING: COMPARISON OF FORECAST PERIODS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

Length of Forecast	Automated (110)		Non-automated (50)	
	Number	Per cent	Number	Per cent
L. T. a month	0	0.00	0	0.00
One month	0	0.00	1	2.00
Two months	0	0.00	0	0.00
Three months	2	1.82	0	0.00
Four months	0	0.00	0	0.00
Six months	3	2.73	1	2.00
One year	56	50.91	30	60.00
One-and-a-half year	2	1.82	1	2.00
Two years	6	5.45	1	2.00
Three years	10	9.09	5	10.00
Four years	5	4.55	1	2.00
Five years	42	38.18	14	28.00
Ten years	2	1.82	0	0.00
Variable	7	6.36	5	10.00

TABLE XXIV

TECHNOLOGICAL FORECASTING: COMPARISON OF FORECAST PERIODS BETWEEN AUTOMATED AND NON-AUTOMATED GROUPS

Length of Forecast	Automated (53)		Non-automated (11)	
	Number	Per cent	Number	Per cent
L. T. a month	0	0.00	0	0.00
One month	1	1.89	0	0.00
Two months	0	0.00	0	0.00
Three months	0	0.00	0	0.00
Four months	0	0.00	0	0.00
Six months	0	0.00	0	0.00
One year	14	26.42	5	45.45
One-and-a-half years	0	0.00	1	9.09
Two years	2	3.77	0	0.00
Three years	4	7.55	0	0.00
Four years	2	3.77	0	0.00
Five years	17	32.08	7	63.64
Ten years	6	11.32	0	0.00
Variable	9	16.98	2	18.18

Comparison by Planning and Decision-making Techniques Employed

The purpose of Question 6 of the questionnaire was to obtain information concerning the relative employment of certain planning and decision techniques. The question reads as follows: "Indicate by check-marks which of the following planning or decision making techniques your company makes use of." The list of specified techniques is shown in Table XXV in which the summary response to Question 6 is presented. Inspection of Table XXV reveals that very few companies in either group, automated or non-automated, make use of certain of the techniques listed. All of the percentages, however, with the exception of that for Game Theory, are higher for the automated group than for the non-automated group. As previously mentioned, "size of company" is likely another causal factor affecting the degree to which certain of these planning and decision methods are used.

TABLE XXV

COMPARISON OF AUTOMATED AND NON-AUTOMATED GROUPS BY PLANNING AND DECISION TECHNIQUES EMPLOYED

Technique	Automated (131)		Non-automated (116)	
	Number	Per cent	Number	Per cent
A. Bayesian statistics	9	6.87	0	0.00
B. Breakeven chart analysis	92	70.23	44	37.93
C. Cost/Benefit analysis	77	58.78	37	31.90
D. Critical path methods	57	43.51	20	17.24
E. DELPHI	5	3.82	1	0.86
F. Economic lot size model	47	35.88	21	18.10
G. Economic order quantity model	58	44.27	27	23.28
H. Game Theory	0	0.00	0	0.00
I. Gantt chart	37	28.24	14	12.07
J. Linear programming	35	26.72	2	1.72
K. Markov-chain analysis	2	1.53	0	0.00
L. Non-linear programming	9	6.87	1	0.86
M. Probability Theory	21	16.03	11	9.48
N. Queuing Theory	7	5.34	0	0.00
O. Regression/Correlation analysis	24	18.32	2	1.72
P. Return-on-investment analysis	113	86.26	70	60.34
Q. Simulation	35	26.72	7	6.03

Indicators of the Impact of Automation on Planning

The increasing application of automation technology to production processes and the increasing magnitude of investment in automated production systems and equipment are indicators of the general impact of automation on managerial planning. For example, James C. Keebler, Editor of *Automation Magazine*, forecasts an investment during 1970 of $15.12 billion for manufacturing automation equipment and related components.[18] Investment of this amount would be a continuation of an existing upward trend. The 1968 survey on automation trends conducted by the Market Research Department of *Automation* reported a continued increase in the use of automatic manufacturing equipment. One indication of this was the percentage of plants, based on 3,701 respondents, planning increased use of automatic production equipment and controls. A summary of this portion of the *Automation* survey is shown in Table XXVI. From the magnitude of the aggregate investment in production automation and the increases in automated systems reflected in Table XXVI, it seems likely that the planning efforts of the individual companies involved will be greatly affected.

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[18] James C. Keebler, *Automation* (January, 1970), p. 9.

TABLE XXVI

PLANNED INCREASE IN AUTOMATIC PRODUCTION EQUIPMENT AND CONTROLS

Type of Equipment or Control	Percentage of Plants Planning Increase
Drive and speed regulation	62.8
Control of sequence operations	55.1
Process sensing and control instruments	42.1
Automatic measuring and gaging	39.6
Automatic weighing	24.3
Tape and punch-card control	28.3
Process analyzers	15.2
Computer control	21.6
Remote control	15.9

Source: 1968 Automation Trends Survey and Forecast, pp. 12-15. (conducted by Market Research Department, Automation magazine).

CHAPTER IV

AUTOMATION AND CONTROL

Introduction

The management function of control is the close companion of the function of planning. Its purpose is to ensure that plans succeed, i.e., that specific objectives are achieved. The controlling process is regarded by Koontz and O'Donnell as: ". . . .one of establishing standards against which performance can be measured, measuring performance, and correcting deviations from the standards or plans."[1] Douglas Sherwin states: "The essence of control is action which adjusts operations to predetermined standards, and its basis is information in the hands of managers."[2] The elements of control include internal auditing, measuring and evaluating organizational performance, and the establishment and maintenance of the management information system.

The purpose of this chapter is to discuss certain effects of automation on the control function and to present the survey results regarding automation and control

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[1]Harold Koontz and Cyril O'Donnell, eds., Management: A Book of Readings (New York: McGraw-Hill, Inc., 1968), p. 505.

[2]Douglas S. Sherwin, "The Meaning of Control," ibid., p. 507.

Control--The Major Reason for Automating

Previous studies have shown that the main reasons companies automate are related to the desire for better control. In a study conducted by the Stanford Research Institute for the U.S. Department of Labor to determine what factors influence managerial decisions to automate, the researchers found management's major objective in automating to be cost reduction. The researchers conclude, in part:

> Cost reduction at the time of automation appears to be the major objective when decisions are made to automate. And it is primarily through the effect of automation on labor productivity that cost reduction is sought....Significant savings can also result from the fact that automated operations tend to produce less scrap and fewer rejects and damaged goods and to require less reworking, less in-process inventory, and less plant space than alternative methods of work.[3]

Control factors are also the most predominant ones in secondary reasons for automating. The Stanford researchers further state:

> ... All of the companies studied reported that they expected automation to improve product quality, accuracy of work, and customer service.
>
> Another aspect of cost reduction is cost stabilization. Automation increases the role of fixed relative to variable costs, thus decreasing the effect on total costs of changes in volume of production.
>
> ... Automation mitigated problems connected with pilferage, goods breakage, shortages of skilled workers, volume fluctuations...[4]

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[3] Richard S. Roberts, Jr., Management Decisions to Automate (Menlo Park, California: Stanford Research Institute, 1964), p. 7.

[4] Ibid., pp. 7-8.

The 1968 survey conducted by _Automation_ reflects findings similar to those of the Stanford Research Institute study concerning management's reasons for automating. In the _Automation_ study, the companies surveyed were asked to indicate their primary and secondary reasons for automating. There were 2,606 responses to this question. The results are shown in Table XXVII which gives, for each specified reason, the percentage of the total number of respondents indicating that as their primary reason for automating and the percentage indicating that as the secondary reason for automating. The reasons for automating related to control are asterisked. The results support the Stanford study conclusion that the most prevalent reason for automating is to reduce costs.

TABLE XXVII

REASONS FOR AUTOMATING MANUFACTURING OPERATIONS

	Percentage of Plants Responding	
	Primary	Secondary
Reduce general costs*	73.4	10.5
Increase production	63.0	14.6
Improve quality*	52.6	20.1
Competition	32.9	17.6
Overcome labor shortage	18.4	21.8
Eliminate scrap loss*	16.8	18.6
Reduce material costs*	11.3	13.2
Other	2.5	2.5

*Control Factor

Source: 1968 _Automation Trends Survey and Forecast_, p. 8. (conducted by Market Research Department, _Automation_ magazine).

An Overview of Effects

The Integration of Control

The basis for control is information. This is true in both the automated and the non-automated company. However, there appears to be a difference with automated systems even though the difference may be more of degree than of kind. Traditionally, the managers of the major activities in a company, whether they be Head of the Sales Department or Vice President for Manufacturing, have had a general understanding of the activities of each other. But they have also had a more or less precise understanding of the boundaries between functional activities. In automated systems functional lines may become more blurred because of a requirement for a high volume of information to flow repeatedly across functional boundaries.[5] In the ideal case accurate and current information would flow smoothly between managers in sales, manufacturing, engineering, finance, etc. In the automated production system the plant becomes the "machine," and collective management becomes its control mechanism. One thing automation means is integration of the physical plant. Its counterpart is "integrated management" which implies an overall company point of view and superior teamwork. The concept, of course, does not apply only to the control

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[5] Cuthbert C. Hurd, "Automation and Management," *Advanced Management Journal* (April, 1964), p. 10.

function of management, but the management information system, the basis for control, is also a major vehicle for facilitating 'integrated management."

Diminished Response Time

Under automation less time is allowed both to sense an unacceptable condition and then to correct it. Management, therefore, has to provide for a much faster reaction time to operating problems. Downtime of the automated production line, for example, is more serious than is an inoperative machine in a conventional plant. The cost of downtime in an automated process or line is very high. It therefore becomes essential to minimize downtime for successful economic performance of the system. This requires quick reaction when trouble occurs and, also, a carefully planned and executed preventive maintenance program. It may be desirable, for example, to pre-schedule routine servicing, tool changing, and similar maintenance functions at intervals when downtime is otherwise required. While the highest level of concern for an inoperative equipment in a conventional plant might be a foreman, automated production line downtime has to be the concern of top management.

The typical high rate of production which automation accomplishes is in itself a characteristic which puts pressure on the organization to respond quickly to emergencies. If process control is lost to any degree such that defective

units of output are being produced, then the defectives come off the line at the same high rate as good units. The cost of continuing to produce faulty product at a high rate could obviously be serious. Quick detection of such a condition is important to preclude losses which might be substantial. A responsibility is placed on management, then, to visualize and anticipate such emergency situations and to develop and prescribe procedures for dealing with them.

In addition to these pressures on physical process control, automation tends to dictate faster reaction time by management for some other reasons. For example, there is likely to be increased stress on management of automated systems to be alert in sensing changes in their product market and to provide for rapid feedback to the organization, particularly production. Even the time allowed management to sense and react to the need for change is likely to be affected. An acceleration in the rate of feedback from "technological frontiers" to the plant may be required. Diebold apparently had this in mind when he expressed this view:

> The reaction time of management must shorten. The time for leeway in adapting to new technologies has disappeared. Companies must keep track of a number of fundamental areas of scientific work and must react rapidly to apply this work when the time is right. They must consciously plan to be the ones who obsolesce not only their own products, but their very industries.[6]

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[6] John Diebold, Beyond Automation (New York: McGraw-Hill Book Company, 1964), p. 20.

Effects on the Capacity to Control

It was previously mentioned that a requirement for handling large volumes of information generally accompanies automation. The volume of data is even greater because information is in a sense "distilled" data. It also appears that there are certain characteristics of automation which dictate more rapid availability of information. The greatly increased complexity of the production "machine" tends to confront management with a much more complex set of control conditions. This seemingly constitutes a threat to the human capacity of management to control.

There appear to be at least two ways in which these effects are mitigated. The first is related to the continuous-flow principle of automation. When the production process is converted from batch or intermittent manual and mechanical production to automatic continuous production, the requirement for many day-to-day discrete decisions is negated. These tend to be middle-management type decisions such as decisions on scheduling, work allocation, stationing materials, work methods, etc.

The second mitigating factor is the availability of electronic data-processing equipment to aid management. For several of the major business information subsystems such as finance and logistics the information tends to be recurring, documentary, internal and historical. These subsystems are generally susceptible to computerization thus relieving

management of a great many repetitive decisions.[7] Furthermore, computers can handle large amounts of data rapidly and, coupled with quantitative techniques such as statistics, operations research, and linear programming, can help provide the answers needed by management to administer the delicately balanced operations of the automated plant. Highly advanced applications may be achieved by direct interface between electronic computers supporting the management information system and the computers controlling the physical production process.

It is not intended to oversimplify or understate the control problems imposed on management by automation. The processing of data and its conversion into information can to a large extent be done by computers, but it remains that management has to provide for the control of a much more complex system under automation.

Survey Results: Control

Criteria for Measuring Organizational Performance

One of the major aspects of controlling is the measurement of the overall performance of a company. An individual company may establish a number of criteria against which the organization's performance is to be measured. Also the

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[7] John Dearden and F. Warren McFarlan, *Management Information Systems: Text and Cases* (Homewood, Illinois: Richard D. Irwin, Inc., 1966), pp. 3-20.

relative importance assigned to certain criteria may vary among companies.

The purpose of Question 7 of the survey questionnaire was to determine if there are differences between the automated and non-automated groups in the importance assigned by management to certain measures of organizational performance. The question reads as follows: "<u>How does your company measure the organization's performance? Using the following list of performance measures, select and indicate by checkmarks, the five (5) which are most important for your company:</u>" The list of specified measures of performance is shown in Table XXVIII which presents the summarized response to Question 7. Of the 131 companies in the automated group, 120 companies responded to this question with useful information, and 111 of the 116 coppanies in the non-automated group provided useful answers.

Table XXVIII shows for each performance measure the number and percentage of companies in the automated and non-automated groups which consider the specified performance measure to be among the five most important. Inspection of the data reveals that the greatest differences in percentages between the automated and non-automated groups are for the performance measures corporate growth, increasing production, innovation, loyalty of employees, market standing, profitability and return-on-investment. The test for difference in population proportions was made for each of these seven

measures. None of the differences in population proportions are significant at the 1 per cent (.01) level. The differences for increasing production, innovation, loyalty of employees, and market standing are significant at the 5 per cent (.05) level. The differences for the other three measures, corporate growth, profitability, and return-on-investment were found to be "not significant."

In Table XXIX the data from Question 7 has been rearranged to show how the specified performance measures are ranked by the two groups. The most interesting aspect of the rankings is the similarity between the two groups. Both groups consider the same five measures of performance (profitability, return-on-investment, corporate growth, customer satisfaction, and sales) to be the five most important. Also, both groups rank productivity sixth in importance and quality of output seventh. Employee turnover, absenteeism and safety record are considered by both groups to be the least important as measures of organizational performance. There are some minor differences in the order of the middle-ranked criteria.

The survey results indicate then that the two groups are similar in terms of the relative importance assigned to various criteria for measuring and evaluating organizational performance.

TABLE XVIII

COMPARISON OF AUTOMATED AND NON-AUTOMATED GROUPS BY MEASURES OF ORGANIZATIONAL PERFORMANCE

Performance Measure	Automated (120)		Non-automated (111)	
	Number	Per cent	Number	Per cent
A. Absenteeism	4	3.33	6	5.41
B. Community & public responsibility	9	7.50	9	8.11
C. Corporate growth	75	62.50	57	51.35
D. Customer satisfaction	68	56.67	64	57.66
E. Employee turnover	4	3.33	8	7.21
F. Increasing production	12	10.00	22	19.82
G. Innovation	21	17.50	8	7.21
H. Loyalty of employees	10	8.33	21	18.92
I. Market standing	39	32.50	21	18.92
J. Productivity	43	35.83	43	38.74
K. Profitability	97	30.83	97	87.39
L. Quality of output	40	33.33	36	32.43
M. Reducing costs	21	17.50	19	17.12
N. Return on investment	86	71.67	67	60.36
O. Safety record	1	0.83	2	1.80
P. Sales	62	51.67	60	54.05
Q. Other	3	2.50	1	0.90

TABLE XXIX

RANKING OF PERFORMANCE CRITERIA
BY ORDER OF IMPORTANCE

Automated Group (120)		Non-automated Group (111)	
Measure	Per cent	Measure	Per cent
Profitability	80.83	Profitability	87.39
Return-on-investment	71.67	Return-on-investment	60.36
Corporate growth	62.50	Customer satisfaction	57.66
Customer satisfaction	56.67	Sales	54.05
Sales	51.67	Corporate growth	51.35
Productivity	35.83	Productivity	38.74
Quality of output	33.33	Quality of output	32.43
Market standing	32.50	Increasing production	19.82
Reducing costs	17.50	Market standing	18.92
Innovation	17.50	Loyalty	18.92
Increasing production	10.00	Reducing costs	17.12
Loyalty of employees	8.33	Com. & public resp.	8.11
Com. & public resp.	7.50	Innovation	7.21
Employee turnover	3.33	Employee turnover	7.21
Absenteeism	3.33	Absenteeism	5.41
Safety record	0.83	Safety record	1.80

Management Information Systems in the Automated and Non-automated Groups

As previously stated, the basis for control is information. The management information system is the means by which management handles the information that is entering, circulating, being generated within and leaving a firm. The type of management information system needed, in terms of whether or not it is computer-based, depends on a number of things. Dearden and McFarlan state:

> In many companies, management is concerned with the extent to which computers should be used to automate their information systems. A more important concern, however, is the adequacy of the management information system. Consequently, it appears to us that it is vital to examine the quality of the management information system first and to consider automating it second. Not all management information can be improved by the use of a computer. Nor does all information generated by a computer qualify as management information.... The most important consideration for the business manager is to have an effective management information system.[8]

Although there can be little disagreement with these comments, Ronald Daniel of McKinsey & Company points out:

> ...the evolution of electronic data-processing systems, the development of supporting communications networks, and the formulation of rigorous mathematical solutions to business problems have provided potentially valuable tools to help management attack its information problems....To an increasing extent, a manager's effectiveness will hinge on the quality and completeness of the facts that flow to him and on his skill in using them. With technology changing at a rapid rate, with the time dimension becoming increasingly critical...it is inevitable that executives will rely more and more on formally presented information in managing their businesses.... developments in management information systems will

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[8] Ibid.

affect the executive in two ways. Not only will the new concepts influence what he is able to do, but they will to a great extent control how well he is able to do it.[9]

Because of the faster pace of operations and the complexity of automated production systems, the volume and speed requirements of the management information system are increased. It follows that firms with automated production processes are likely to be supported by computer-based information systems. While the potential benefits of computer-based information systems are great and they may be absolutely necessary to successfully manage and control, the introduction of such a system "generates its own unique problems"[10] for management. Rosove attributes these problems primarily to three interrelated sets of conditions:

> (1) the widespread lack of familiarity of managers and administrators with the development process for information systems; (2) the use of an irrelevant model of hardware system development for the management of the information system development process; and (3) the incompatibility between existing management organization and administrative procedures and the unique nature of the information system development process.[11]

Cuthbert Hurd states that where computer-based information systems are installed there is "an intensification of every management question."[12] Hurd also sees a modification

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[9] D. Ronald Daniel, "Management Information Crisis," _Management: A Book of Readings_, _op. cit._, pp. 526-528.

[10] Perry E. Rosove, _Developing Computer-Based Information Systems_ (New York: John Wiley and Sons, Inc., 1968), p. 1.

[11] _Ibid._, p. 25.

[12] Hurd, _op. cit._, p. 11.

of management's job resulting from the introduction of such management information systems:

> The new designs and equipment that will still further modify the manager's job probably lie in the field of digital data transmission. Included in digital data transmission are consoles, displays, and the interfaces between automated production systems and communications as well as the interfaces between communications equipment and data processing equipment.[13]

One indication then of the effect of automation on management in terms of control is the relative complexity of the management information system. The purpose of Question 8 of the questionnaire was to obtain information on the numbers of companies which have certain types of management information systems. The question reads as follows: "Which of the following descriptions best characterizes your Management Information System?" The classifications used are shown in Table XXX. In the automated group 113 companies made useful responses, and in the non-automated group 100 companies gave useful answers. Table XXX shows the results for the two groups. The majority (69.03 per cent) of the automated group indicated that they have computer-based management information systems. Thirty-five per cent of the non-automated group have developed computer-based management information systems. Using these percentages, the test for difference in population proportions indicates a difference significant at the 1 per cent (.01) level. This suggests that management of automated companies are more likely to feel the effects

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[13] *Ibid.*

cited by Dorf and to encounter the problems pointed out by Rosove.

TABLE XXX

COMPARISON BY TYPE OF MANAGEMENT INFORMATION SYSTEM

	Automated (113)		Non-automated (100)	
	Number	Per cent	Number	Per cent
A. Manual data processing	13	11.50	40	40.00
B. Mechanical data processing	9	7.97	10	10.00
C. Electromechanical data processing	13	11.50	15	15.00
D. Electronic data processing (batch system)	58	51.33	31	31.00
E. On-line, real-time electronic data processing	20	17.70	4	4.00

CHAPTER V

AUTOMATION: ORGANIZING AND STAFFING

Introduction

The managerial functions of organizing and staffing are closely related as explained by the following definitions. In defining organizing Koontz and O'Donnell state: "The task of organizing is to establish a system of activity groupings and authority relationships in which people can know what their tasks are, how their tasks relate to one another, and where authority for decisions needed to accomplish these tasks rests. Organizing thus establishes an environment for performance by individuals operating in a formally structured group."[1] The same authors describe staffing as: "...the management function that has to do with putting people into the framework of the organization."[2]

The purpose of this chapter is to discuss certain effects of automation on management in terms of the related managerial functions of organizing and staffing and to present the pertinent portions of the survey results.

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[1]Harold Koontz and Cyril O'Donnell, eds., *Management: A Book of Readings* (New York: McGraw-Hill, Inc., 1968), p. 174.

[2]*Ibid.*, p. 288.

An Overview of Effects

Effects on Management Structure

Looking at the past, one observes that basic changes in production technology have been accompanied by revised forms of organization. The type of organization suitable for the "craft system" became unsuitable for production methods brought in by the industrial revolution. As we proceeded toward mechanization for "mass production" and the size of manufacturing concerns increased, the organization, including the management structure, underwent further reconfiguration. It may be that the basic change in production technology represented by automation requires another type of management structuring.

Some of the effects of automation on some managerial functions have already been discussed in preceding chapters. Professor Julius Rezler has noted a relationship between changes in functions and the form of the organization:

> There is a significant relationship between functions and the organizational framework in which they are performed. A change in the functions will cause a corresponding change in the organization....certain managerial functions are changing under the impact of automation. Therefore, it is assumed that they will affect both the organization of the firm and the place and role of individual managers within.[3]

There are differences among writers, however, in their evaluation of the magnitude of such changes resulting from

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[3] Julius Rezler, "Managerial Functions in the Era of Automation," Advanced Management Journal (April, 1964), p. 6[illegible].

automation. Simon predicts that: "the business organization in 1985 will be a highly automated man-machine system, and the nature of management will surely be conditioned by the character of the system being managed."[4] In contrast, Melvin Anshen believes: "A new production technology in the form of automated processing of materials will not lead to radically new forms of management organization."[5]

A core question concerning the effects of automation on the structure of management is whether or not automation tends to reverse the trend toward decentralization. As the size and scope of business organizations increased, particularly in the twentieth century, it became increasingly necessary to departmentalize the organizational units. It was no longer feasible to make all decisions on the top executive level. Now, automation and related advances in information technology may be reducing the necessity for decentralization and the delegation of authority to lower managerial levels. A degree of recentralization is therefore likely. Rezler points out that: "Major changes caused by automation in the function of decision-making has already begun to affect the structure of managerial organization, especially the system

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[4]Herbert A. Simon, The Shape of Automation for Men and Management (New York: Harper & Row, 1965), p. 27.

[5]Melvin Anshen, "Managerial Decisions," Automation and Technological Change, ed. John T. Dunlop (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962), p. 66.

of distributing authority."[6] Anshen expresses a similar view:

> The marked trend toward decentralization of decision making in large organizations probably will be slowed and in part reversed. The ability to transmit information rapidly and to accomplish mass data processing economically on centrally-located computers will make it possible and desirable to return to headquarters a share of the decision-making responsibility that has been pushed to regional and district offices or to the managers of product groups.[7]

At the 1970 "Symposium on Automation and Society" at the University of Georgia, Dr. Joseph Harrington, Jr., expressed his belief that a process of "managerial refusion" is taking place: "Management is being reformed into its original monolithic structure (but as a group rather than one individual)."[8]

The effect of recentralization on management is likely to vary with the managerial level on which individuals operate. Previous research findings indicate that the impact of automation is the greatest on the two lower managerial levels. At the supervisory level Davis found:

> Computer installations have moved some decision-making and control upward to higher levels....this action leaves operating supervisors with the feeling that they lack the influence they once had.... The new machines and systems are a severe challenge to a marginal supervisor, and there is a new programming

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[6] Rezler, op. cit.

[7] Anshen, op. cit., p. 80.

[8] Joseph Harrington, Jr. (Keynote Address for the Second Annual Georgia-Reliance Symposium on Automation and Society, University of Georgia, Athens, Georgia, April 6, 1970).

ility to threaten his security and may even replace him.[9]

With regard to middle managers, however, Rezler states: "...of all managerial levels, middle-management is affected most seriously by the functional and organizational changes caused by automation."[10] Simon's comments support this opinion.

> There is undoubtedly a rough, but far from perfect, correlation between a manager's organizational level and the extent to which his decisions are programmed....a great many middle-management decisions that have always been supposed to call for the experienced human judgment of managers and professional engineers can now be made at least as well by computers as by managers.... a large part of the total middle-management job consists of decisions of the same general character as those that have already yielded to automation. The decisions are repetitive and require little of the kinds of flexibility that constitute man's principal comparative advantage over machines. We can predict with some confidence that persons making such decisions will constitute a much smaller fraction of the total occupied group....[11]

In writing about the impact of automation on management organization Anshen cites the following possible consequences for the middle-management group:

> 1. An upward shift of the boundary between planning and performance, as a result of which many planning responsibilities will be removed from middle-level managers.

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[9] K. Davis, "Human Adjustment to Automation," Advanced Management Journal (January, 1964), pp. 22-23.

[10] Rezler, op. cit., p. 64.

[11] Herbert A. Simon, "The Automation of Management," Management: A Book of Readings, op. cit., pp. 593-595.

> 2. A reversal of the recent trend toward decentralized operations, with top management taking on a much larger share of the innovating, planning, and creating functions.
>
> 3. Radical reorganization of middle management structure...
>
> 4. The appearance of a sharper, more impenetrable demarcation between the top and the middle of the organizational structure.[12]

Shils concludes that the requirement for shorter reaction times imposed by automation will affect the management structure:

> The greater number of levels of responsibility in the conventional plant will be reduced by automation; there will be fewer people between the top and the bottom man .... If a machine breaks down, there will be some delay if information has to be passed up the traditional lines of authority, across, and then down again to the right specialist in a staff department. Under automation, the specialist may have to be called in directly ...[13]

It is difficult to quantitatively assess the effect of automation on management structure. Simon believes that organizations will retain their basically hierarchical structure.[14] Management, taken collectively, may continue to constitute about the same percentage of the total work force. Based on the findings of past research, however, there is apparently a tendency toward recentralization which affects the two lower levels of management, particularly

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[12] Anshen, *op. cit.*, p. 73.

[13] Edward B. Shils, *Automation and Industrial Relations* (New York: Holt, Rinehart and Winston, Inc., 1966), pp. 94-95.

[14] Simon, *The Shape of Automation for Men and Management*, *op. cit.*, p. 110.

middle management. Also there is a general consensus that the kinds of activities that characterize middle management are highly susceptible to automation. Middle management seems to have benefited most from decentralization. It appears that it is the most affected by the process of recentralization.

Increase in Special Support Groups

In the traditional production environment, the master workman was familiar with the tasks of each of his journeymen. There was little requirement for the journeyman to contribute skills or knowledge which his foreman might not possess. His role was to produce. At a later stage, the owner or manager of a simple factory retained essentially this same relationship with his workmen.[15] But as technology advanced and production processes became more complex, the relationship began to change. It became impossible for the manager, or even foreman, to have knowledge of the tasks of all those working under his supervision. Mastery of all aspects of the production process by any one individual became less and less feasible. It became necessary to use specialists in various phases of the process.

An apparent effect of automation on the organizational structure is a rise in the number and importance of technical

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[15] Andrzej Zalewski, "The Influence of Automation on Management," Employment Problems of Automation and Advanced Technology, ed. Jack Stieber (New York: St. Martin's Press, Inc., 1966), pp. 355-356.

and other special support groups. It has already been mentioned several times that manufacturing automation means integration of the production process. However, the advantages that are derived from integration depend on the precise functioning of each element in the system. Such highly integrated production systems require close collaboration between various specialists to be successful. In a recent study on automation, one finding which the researchers reported was:

> Generally, technical support groups which bolster production operations have expanded in numbers and importance at both plant and corporate levels.... faster paced operations, more delicately balanced units, growing dependencies between departments and plants...have all been factors in enhancing the position of support personnel.[16]

Also the need for coordination and control over decisions for large commitments of resources and to reduce costs of disruption have helped to strengthen technical support groups. So has increased equipment and system complexity. Examples of the impact of automation in terms of the rise in support groups include: "the creation or expansion of quality control departments, the initiation of operational study groups and facility planning teams, and the growing importance of systems, computer, and electronic maintenance groups."[17] Another example is the growth in the number of companies establishing special groups to be responsible for automation

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[16] Elmer H. Burack and Thomas J. McNichols, "Management and Automation Research Project: Final Report" (Chicago: Illinois Institute of Technology, 1968), p. 3.

[17] *Ibid.*

planning. This increasing trend is reflected in Figure 3 which shows, for the period from 1957 to 1970, the percentage of plants reporting the establishment of special automation planning groups. The percentage for 1970 is estimated.

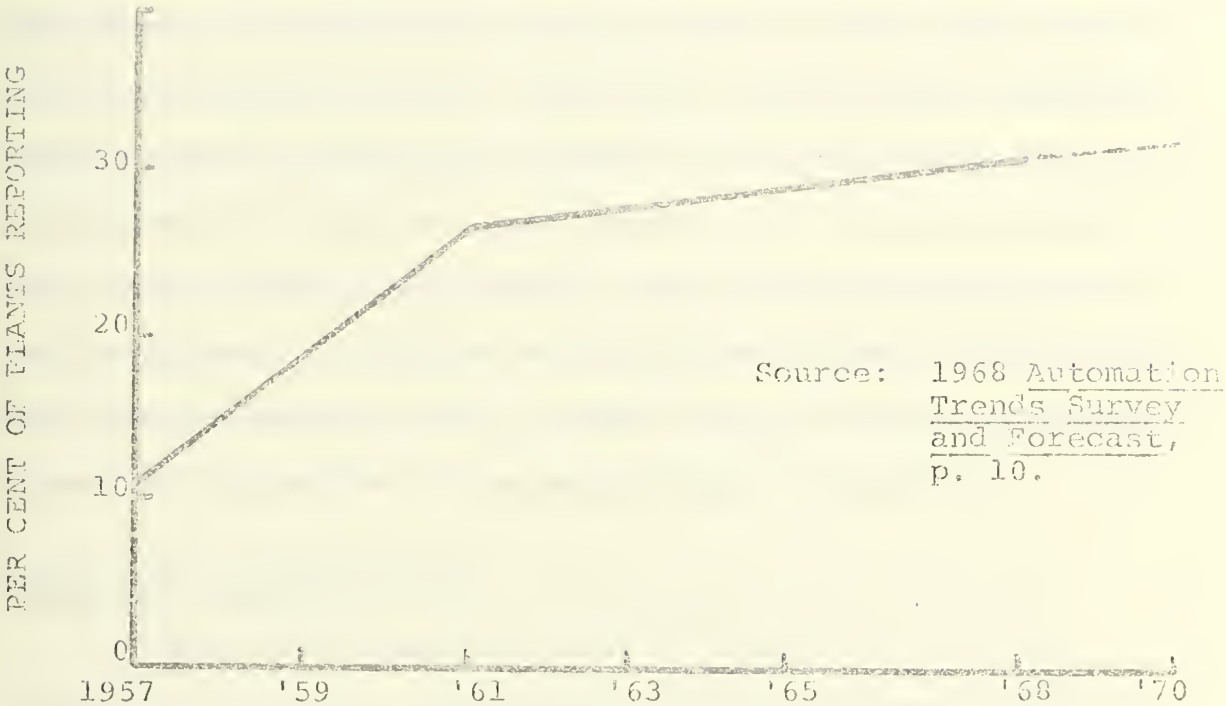

Figure 3. Growth Trend in Special Groups Responsible for Automation Planning.

The rise in the importance of specialists associated with automation is likely to result in changed organizational relationships. Burack and McNichols reported, for example, that:

> Staff personnel are increasingly displacing areas of authority and prerogatives of line managers...The clustering of needed skills and technical knowledge in support groups, with the obvious backing of higher level management, has narrowed the scope of the

> production manager's operating jurisdictions. The need for supervisors to "check with" support groups has correspondingly increased ... Ofttimes new power centers are developed in an organization based upon exclusive possession of specialized knowledge.[18]

As a result there are likely to be implications for the organization such as the restructuring of authority, the realignment of functional relations and possibly even changing career opportunities. Therefore, an important and challenging task of management becomes the coordination of specialists in technical application with line supervisors and others in the organization. Not the least important is the development of productive relations between the specialists and management itself. These are in reality additional facets of the problem of organizational integration.

Managerial Qualifications

A pertinent question posed by automation is what effects the shift to automated production systems has on the qualifications of individuals needed to manage the enterprise. First, fruitful results from automatic production systems often require a fundamental change in approach and a willingness to rethink the problems of the entire business in terms of ultimate goals and final product. These are not technical questions. They are problems of method, organization, and attitude, and they require superior managerial imagination, skill and experience to solve them. Automation

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[18] *Ibid.*, pp. 44-45.

requires careful "design" of the total system with regard to technological, economic and human considerations. The only group with the perspective of the whole business who is in a position to establish these broad design criteria is top management. Therefore, automation places a more critical system design reponsibility on management. This requires persons with broad perspectives and a capacity for identifying design criteria, setting system goals and fixing problem parameters.[19]

Previous research findings support the hypothesis that as production becomes more automated there is a tendency toward redefinition of management credentials. In a study of 44 companies including 72 plant sites the researchers found:

> Technological change in these process and process-type firms are a major factor in bringing about substantial redefinitions of supervisory and managerial functions and long standing career patterns. More technically based operations, closer operating relationships between units, higher rates of output, and more control instruments are among the technological factors reshaping job demands. Management's interpretation of work system needs is shifting promotion credentials to a heavy emphasis on the degree holder .... Those process operations combining large numbers of variables call for complex problem-solving skills thought to require the technical degree holder .... Plants of production units characterized by advanced levels of process technology tend toward personnel with formal, technical credentials while less advanced operations utilize considerably greater numbers of experience-trained employees.[20]

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[19] James R. Bright, Automation and Management (Norwood, Massachusetts: The Plimpton Press, 1958), p. 231.

[20] Burack and McNichols, op. cit., pp. 1-20.

Therefore, it appears that the movement to automated production systems is accompanied by an increased emphasis on higher formal education for management personnel or potential management personnel. At the same time experience is apparently being downgraded in importance as a criterion for managerial qualification. These phenomena are being observed because with the introduction of pronounced, interdependent systems, a basis is established for the modification of management qualifications. In more advanced automated systems, characteristic features of technical complexity, interdependence, and comprehensive controls create emphasis on inferential analysis, problem solving and system-wide orientation.[21] According to Shils: "Automatic production is likely to increase the advantages of formal training in management, because each plant must operate as a unified whole, and such operation is best achieved by techniques of managerial planning and control, which have to be acquired by formal training."[22]

<u>Effects on Management of the Work Force</u>

Several studies have shown that the major and most common reason given for automating production is to achieve reduced costs, primarily through direct labor reductions. Killingsworth notes: "Almost by definition, automation is

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[21] <u>Ibid.</u>, p. 24.

[22] Shils, <u>op. cit.</u>, p. 269.

labor saving. The chief, and most universal reason for installing automation equipment is to save on direct labor costs. Savings of 75 to 95 per cent of the manpower of particular operations is not unusual."[23]

While much attention has been focused on the difficulties created by automation for unskilled workers, Otto Eckstein believes that the large group of workers in the semi-skilled category are the ones primarily affected by automation. He states:

> In my view the group at the very center of the automation problem consists of the semi-skilled who man the assembly lines in such mass production industries as autos, meat packing, rubber, and in continuous process industries such as steel, chemicals, and petroleum refining .... the technology of assembly lines has been changed by the coming of electronically controlled and programmed equipment .... and with the coming of the automated equipment, the total labor force contracted considerably....the process of automation is far from complete and the resultant rapid increases of productivity will reduce requirements for additional workers and displace some workers now on the job .... technological change has put many of the jobs (of the semi-skilled) in peril, and when displacement comes, it poses particularly difficult problems of adjustment .... This group of workers will continue to constitute the most serious human problem of adjustment to automation.[24]

A major task for management resulting from the labor saving effect of automation is the readjustment of the work

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[23] C. C. Killingsworth, "Automation in Manufacturing," IRRA Proceedings (December 28-30, 1958), p. 25.

[24] Otto Eckstein, "Perspectives on Employment Under Technical Change," Employment Problems of Automation and Advanced Technology, ed. Jack Stieber (New York: St. Martin's Press, Inc., 1966), pp. 96-97.

force to the new labor requirements. Most studies indicate that many companies have been careful to avoid mass dismissal of their employees, if possible, and have tried to solve this problem by retiring older workers or by not replacing employees who leave the company in the course of natural attrition. The remaining displaced workers have often been absorbed by internal transfers. In a study of seven companies which had undergone automation, Richard S. Roberts, Jr., of the Stanford Research Institute reported: "Management in all of the firms wanted to avoid creating hardship for employees as a result of automation. In all cases, transfers were to be effected and advantage was to be taken of normal attrition to avoid layoffs."[25] However, not in all cases where jobs are eliminated by automation can layoffs be avoided. As Eckstein points out, many workers have been laid off, especially in the process of mass production industries converting to automation. In these cases management has the additional task of facilitating the separation of these workers from the work force smoothly, and to alleviate the loss of their jobs by paying severance pay or similar compensations.

Automation also affects the administration of the work force because of changes in some skill requirements

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[25] Richard S. Roberts, Jr., "Management Decisions to Automate" (Menlo Park, California: Stanford Research Institute, 1964), p. 44.

resulting from automated production. It has been much debated whether or not automation requires upgraded skills. Regardless of the answer to this, Bright has observed that while automation renders certain skills and occupations obsolete, it also demands new skills and creates new jobs.[26] Changes in skill requirements create tasks of a different nature for management. As automation eliminates certain skills and jobs, and creates a need for new skills and jobs, it becomes necessary to undertake the training or retraining of workers for the new jobs and to establish new job classifications. Training for work in automated production requires the development of new training methods and training content. For example, in the past, the worker had to be shown how to run a machine or to perform a hand operation, and was given direct control over the machine or tool. With automatic equipment, the instructor's job may be to teach the worker to keep his hands off the machine, leaving adjustments and repairs to the professional or technical maintenance staff. Also the new jobs must be classified, their contents described and analyzed and determinations made as to what rating factors are important. The traditional job evaluation system has grown up under the manual system of production. Under automation there are radical changes in

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[26] James R. Bright, "Does Automation Raise Skill Requirements," Harvard Business Review (July-August, 1958), pp. 85-98.

job content, so that factors previously having high ratings and factors having low ratings may decrease or increase respectively. Management has to participate in these determinations.

To illustrate automation's effect on manpower requirements Figure 4 (based on 1968 <u>Automation Trends Survey and Forecast</u>) shows the shifting demand for maintenance personnel versus operating personnel in automated plants. Figure 4 shows the percentage of plants indicating that automation had resulted in a requirement for less personnel, the same number of personnel or more personnel for maintenance versus operations. The two sides of Figure 4 are nearly mirror images of each other, showing that 53.7 per cent of the plants indicated an increased requirement for maintenance personnel while 49.3 per cent showed a decreased requirement for operating personnel. These figures provide some idea of the magnitude of the manpower management task created by automating production.

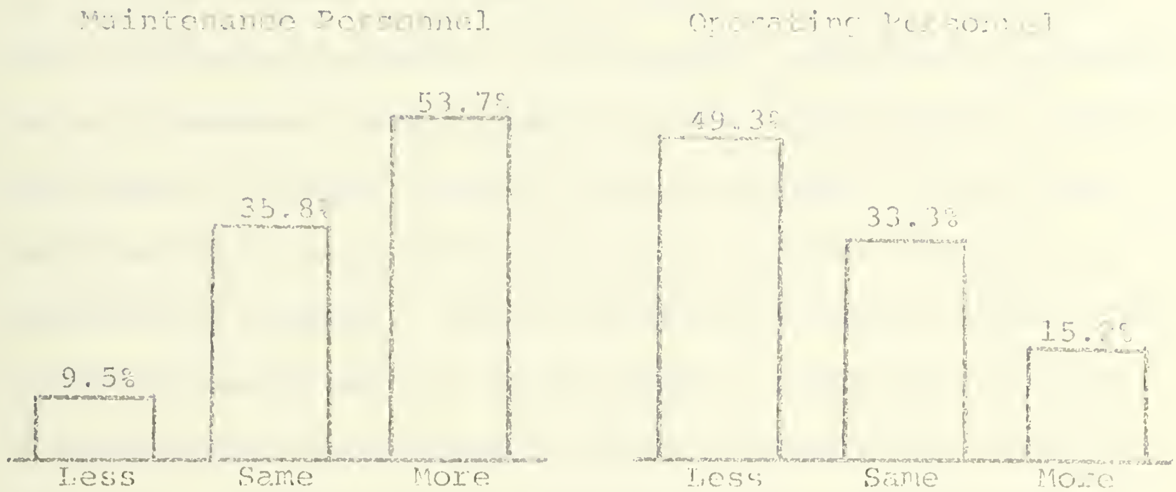

Figure 4. Automation's Effect on Requirements for Maintenance Personnel versus Operating Personnel.

Source: 1968 <u>Automation Trends Survey and Forecast</u>, p. 9.

<u>Effects on Wage Administration</u>

Frederick Taylor and his successors in the scientific management movement were the creators of the theory and practice of systematically trying increments of human effort to increments of financial reward. In other words, scientific management is the parent of modern wage incentive plans which include piece-rate methods, group incentive plans, and a great number of variations. As mechanization for mass production took place, incentive methods of wage determination gained in popularity, and today such plans are widely accepted by management--but less so by labor unions and workers.

Automation, however, raises questions with regard to the appropriateness of incentive wage procedures, particularly piece-rate methods. In automated production processes the work becomes "machine paced" rather than "worker paced." The worker no longer controls his own output. Also, the contribution of one worker cannot be isolated from the contribution of another. Since the speed of work is determined by the equipment and not by the worker, piece-rate methods of determining wage payments become inappropriate. Automation, then, creates another important task for management--the determination of appropriate new wage criteria. A likely eventual consequence of automation is that more workers will be paid on a day-rate basis or even a salaried basis. The determination of actual wage criteria, however, is likely to present management with difficult problems. Shils depicts the situation as follows:

> It is not enough for management to know that automation will possibly require changes in thinking about job evaluation and wage policies .... The major issue to be faced is, what to do about the dilemma of the "compensation basis"?
>
> Since the operators no longer control quantity and quality--if they exert less physical and mental effort, if working conditions improve by automation and chance of accidents lessens, if fewer production decisions are made by the operator, and if less skill knowledge, and experience are required on certain jobs--then what should be the criteria for wages? Should employees be paid less because they contribute less; or more, because production is rising as a result of automation? If more, then on what basis?[27]

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[27] Shils, _op. cit._, pp. 223-224.

While it is probable that more workers will be paid on a day-rate or salaried basis, management may still be able, under certain conditions, to make use of group incentive wage methods. For example, where it can be demonstrated that joint participation contributes to the success of the performance and results can be measured, then it may be possible for management to develop an appropriate group incentive wage formula. Some writers have suggested that management, under automation, will face union demands for new forms of worker remuneration such as "responsibility pay," "tension money," and "lonely money." Charles R. Walker has summarized the task of management with regard to wage criteria under automated production in the following manner:

> ...many companies are today seeking more appropriate methods of paying for work done in an age of ever-changing technology. Some are experimenting with new varieties of profit-sharing plans; others are putting hourly wage-earners on salary. One very science-based corporation is conducting research to answer the question: "Just what are we paying for?" (1) With the new technologies in some departments, should we not be paying day rates rather than piece rates? (2) Would we not do well to put a larger portion of our factory personnel on salary? (3) What are we really paying for, or what would we like to pay for: skill, effort, seniority, professional or craft experience, education, flexibility, loyalty or what?[28]

[28] Charles R. Walker, Modern Technology and Civilization (New York: McGraw-Hill Book Company, Inc., 1962), p. 225.

Survey Results: Organizing and Staffing

Comparison of Wage Plan Pattern

One of the objectives of the questionnaire to companies was to determine if there are yet discernible differences in the types of wage plans for production workers found in companies having automated production versus those found in use in non-automated companies. Thus, in Question 9 companies were asked: "For your production workers what type or types of wage payment plans do you use? Using the following list indicate the one or more types of plans that you use." The choices provided were daywork, piecework, group plan, and other.

The daywork plan refers to all straight time-payment plans used in paying workers, although the hour is the time unit most commonly employed. The daywork plan is the simplest type of wage plan, and is the easiest to compute and to understand. It does not provide incentive for increased production. Piecework is the most widely used incentive plan. Under piecework, wages are determined by the number of pieces or units of work that are completed. The worker receives a prescribed amount (the piece rate) for each unit completed. His earnings consequently vary with output. The group type of wage plan provides for incentive bonuses based upon group performance. Earnings of individual workers are computed by prorating the bonus or premium produced by the group. Other types of wage plans include a

number of variations, usually incorporating some form of incentive.

In response to Question 9, 130 companies out of the 131 in the automated group gave usable answers while in the total non-automated group of 116 companies useful answers were given by 114 companies. In analyzing the response to Question 9 it is interesting to note that the combined results for the total of 244 companies show that 206 companies (84.43 per cent) use daywork wage plans. This large percentage of companies using the daywork plan probably reflects in part the influence of labor unions in wage plan determination, even in many instances where output standards could be readily set and thus incentive plans installed. The piecework plan was reported in use by 68 (27.87 per cent) of the total of 244 companies. Forty companies (16.39 per cent) indicated that they use a group plan, and 12 companies (4.92 per cent) gave "other" responses all of which were some form of incentive plan, primarily the Standard Hour Incentive plan which incorporates some incentive features in a basic daywork plan. Seventy-six companies (31.15 per cent) indicated that they use more than one type of wage payment plan.

The response to Question 9 for the two groups, automated and non-automated, is shown in Table XXXI. As would be expected the percentage of companies in the automated group using the daywork plan is greater than the corresponding

percentage for the non-automated group. Also, the percentage of automated companies using the piecework plan is less than the percentage of non-automated companies using the piecework plan. The survey results further show a higher percentage of the automated group using a group plan. The test for difference in population proportions was made for each of these three types of wage plans as well as for the piecework and "other" types of incentive plans combined. For the daywork plan the results of the test indicate a difference in population proportions between the automated and non-automated groups significant at the 10 per cent (.10) level. The differences for the piecework plan, the group plan and the combined piecework and "other" incentive plans were found to be "not significant."

TABLE XXXI

COMPARISON BY TYPE OF WAGE PLAN

	Automated (130)		Non-automated (114)	
	Number	Per cent	Number	Per cent
Daywork	115[a]	88.46	91	79.82
Piecework	33	25.38	35	30.70
Group Plan[b]	25	19.23	15	13.16
Other	5	3.85	7	6.14

[a]Includes companies indicating their production workers paid on salary basis.

[b]Includes companies indicating their production workers on a profit sharing plan.

Thus, even though the results in terms of relative percentages are all in the expected direction, only the difference between the two groups with regard to the daywork plan is significant, even at the 10 per cent level. As previously mentioned, the high percentage of non-automated companies using daywork plans is probably to a large extent the result of union influence in determining the type of wage plan to be employed. Also, even in non-automated production processes there are many types of jobs for which it is difficult to develop production standards upon which to base a piecework plan.[29] On the other hand the existence of piecework and other incentive plans in a percentage of automated companies not significantly different from the percentage of non-automated companies using such plans suggests a certain rigidity in wage plans even after automating production. Robert L. Aronson comments on his experience regarding this phenomenon as follows:

> With the emergence of interest in automation, it was confidently expected by many students that piecework and incentive systems of wage payment would virtually disappear from the scene, at least in automated industries. Machine-paced production and the growth in the number of indirect and non-production workers create a presumption against incentive methods of wage payment. Experience, including our own observations in a number of plants, suggests that the concept of incentive wage payment is made of sturdier stuff. In no case which we

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[29] Herbert J. Chruden and Arthur W. Sherman, Jr., *Personnel Management* (Cincinnati, Ohio: Southwestern Publishing Company, 1963), pp. 574-575.

examples did we find complete abandonment of incentive wages as a result of technological change.[30]

Thus, based on the survey results it appears that to date no great differences have emerged in the pattern of wage plans in use for automated and non-automated production workers.

Production Work Force Skill Requirements

In Question 10 the investigator was interested in obtaining information which would enable comparisons, for several industries, of the numbers (percentages) of production maintenance personnel versus the numbers (percentages) of production operatives in automated and non-automated plants. It was also the objective of Question 10 to make comparisons for several industries of the percentages of production operatives in the skilled, semi-skilled and unskilled categories in automated and non-automated plants. Question 10 reads as follows: "Would you please attach to this returned questionnaire a list of occupational skill classifications for your production employees, showing the number of employees in each skill. Please use the standard classifications from the U.S. Department of Labor Dictionary of Occupational Titles. For Example: 585,380 Cutting-machine fixer (textile)."

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[30] Robert L. Aronson, Jobs, Wages and Changing Technology (Ithaca, New York: New York State School of Industrial and Labor Relations, Bulletin 55, July 1965), p. 46.

The response to Question 10 was poor. Many companies in both groups indicated that they do not use the Department of Labor classification system. A number of companies in both groups frankly stated that it would be too time consuming to compile the requested information. Typical responses were: "We have no formal classification;" "We do not have a cross reference to the Department of Labor classifications;" "Do not have available;" "It would take considerable time to assemble this data."

Twenty-three companies (17.56 per cent) in the automated group did provide some form of production employment list; however, only 11 of these companies (8.40 per cent) had made a breakdown of workers suitable for analysis. In the non-automated group 19 companies (16.38 per cent) provided a list but only 8 of them (6.90 per cent) were in a form suitable for analysis. The response did not allow an analysis by industry nor did it allow a comparison in terms of maintenance personnel versus operatives.

Using the 11 useful responses from the automated group and the 8 from the non-automated group it was possible to make an aggregate comparison (not by industry) in terms of skilled and semi-skilled versus unskilled production workers. The data is shown in Tables XXXII and XXXIII for the automated and non-automated sub-groups respectively. The range in the percentage of unskilled production workers for the automated sub-group is from 0% to 31%. The corresponding

range for the non-automated sub-group is from 16% to 67%. The average of the unskilled percentages is 12.5% for the automated sub-group and 34% for the non-automated sub-group. The percentage of unskilled workers was also computed for both sub-groups by the ratio of total unskilled in the sub-group to total production workers in the sub-group. Expressed as percentages these ratios are 9.2% and 34% for the automated and non-automated sub-groups respectively.

Based on a comparison of these two small sub-groups the percentage of unskilled workers in production is considerably less for the automated sub-group than for the non-automated sub-group. Or stated the other way, the percentage of skilled and semi-skilled production workers is a great deal higher for the automated sub-group than for the non-automated sub-group. One might draw the conclusion from this that management of automated production facilities always faces the task of recruiting, training and managing a better educated and more skilled work force. But, even for these two small sub-groups, it can be seen that the ranges of unskilled percentages overlap--i.e., some of the companies in the automated sub-group have a greater percentage of unskilled production workers than do some of the companies in the non-automated sub-group. Therefore, although the figures for the two sub-groups overall indicate increased skill requirements in the automated plant, it is hazardous

to make a general conclusion. J. H. G. Crispo makes the following observation regarding this point:

> ...in particular settings automation can have very mixed effects on job content. This is what has made Professor James Bright and others very leary about predicting that the net effect of automation will be to upgrade skill requirements. Since experience to date has in fact varied widely from one application of the new technology to another, the problem of arriving at any acceptable conclusions in this respect may remain for some time to come. Ultimately the effect on job content will depend largely on how management chooses to arrange the remaining human requirements in any given production process.[31]

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[31] John H. G. Crispo, "Summary Report" on the North American Joint Conference on the Requirements of Automated Jobs and their Policy Implications held in Washington, D. C., on the 8th--10th December, 1964 (Paris: Organization for Economic Co-operation and Development, 1965), p. 31.

TABLE XXXII

PERCENTAGE OF UNSKILLED PRODUCTION WORKERS
IN ELEVEN PLANTS FROM THE
AUTOMATED GROUP

	Skilled and Semi-skilled	Unskilled	Total	Per cent Unskilled
Company A	176	79	255	31%
Company B	154	20	174	11%
Company C	64	29	93	31%
Company D	313	39	352	11%
Company E	47	7	54	13%
Company F	260	0	260	0%
Company G	750	0	750	0%
Company H	1615	0	1615	0%
Company I	803	270	1073	25%
Company J	313	3	316	1%
Company K	145	25	170	15%

TABLE XXXIII

PERCENTAGE OF UNSKILLED PRODUCTION WORKERS IN EIGHT PLANTS FROM THE NON-AUTOMATED GROUP

	Skilled and Semi-skilled	Unskilled	Total	Per cent Unskilled
Company L	25	51	76	67%
Company M	50	32	82	39%
Company N	43	14	57	25%
Company O	149	29	178	16%
Company P	287	317	604	52%
Company Q	86	28	114	25%
Company R	158	68	226	30%
Company S	405	80	485	16%

Comparison of Management Profiles

It seems desirable at this point to first briefly review some of the information concerning the survey of individual managers which was conducted to provide certain inputs for this study which could not be obtained by means of the survey of companies. The survey of managers and the questionnaire used were described in detail in Chapter I. Of the 495 managers to which questionnaires were sent, 216 managers returned usable data prior to the cut-off date. Thus an overall useful response rate of 43.64 per cent was experienced.

Part I of the questionnaire was designed, in part, to obtain data enabling a comparison of the management profile in the automated production environment with the management profile in the non-automated production environment. The factors considered in the comparison are age, number of years of managerial experience and level of education. A total of 215 managers responded to the request for their age--115 of these being from managers of automated firms and 100 from managers of non-automated firms. The distribution of managers by age group is shown in Table XXXIV. Detailed analysis of the age data indicates a slightly younger group of managers from the automated firms. The mean ages are 43.56 years and 44.41 years for the automated and non-automated groups respectively. The median ages are 44 years for the automated group and 45 years for the non-automated

group. The automated group is bi-modal at 35 and 47 years of age, and the mode for the non-automated group is 46. The youngest third of the managers in the automated group are 38 years of age or less while the youngest third of the managers in the non-automated group are 40 years or less. The oldest third of managers in both groups are 48 years of age or more.

TABLE XXXIV

DISTRIBUTION OF MANAGERS
BY AGE GROUP

Age Group	Automated (115)		Non-automated (100)	
	Number	Per cent	Number	Per cent
Under 26	2	1.74	0	0.00
26-30	12	10.43	7	7.00
31-35	16	13.91	13	13.00
36-40	13	11.30	15	15.00
41-45	19	16.52	14	14.00
46-50	24	20.87	27	27.00
51-55	12	10.43	12	12.00
56-60	10	8.70	8	8.00
61-65	7	6.10	3	3.00
Over 65	0	0.00	1	1.00

In response to the request for the number of years of managerial experience, 114 managers from automated firms and 99 managers from non-automated firms provided data. The

distribution of managers by years of managerial experience is shown in Table XXXV. Analysis of the data indicates that the group of managers in automated firms have an average of 13.2 years of managerial experience whereas the average for the group in non-automated firms is 13.8 years. The median is 13 years for the automated group and 12 years for the non-automated group. The mode is 20 years for both groups. Thus, the survey results show the group of managers from automated firms as having slightly fewer years of experience.

TABLE XXXV

YEARS OF MANAGERIAL EXPERIENCE

Years of Experience	Automated (114)		Non-automated (99)	
	Number	Per cent	Number	Per cent
0-5	29	25.44	19	19.19
6-10	14	12.28	19	19.19
11-15	28	24.56	24	24.25
16-20	28	24.56	20	20.20
Over 20	15	13.16	17	17.17

The survey results concerning the level of education for the two groups are presented in Table XXXVI. The group sizes are 116 and 100 for the automated and non-automated groups respectively. Table XXXVI clearly shows a higher level of education for the group of managers in the automated

firms. The percentage of managers in the automated group having graduated from college or attained a higher level of education is 62.07 per cent. The corresponding figure for the non-automated group is 43.00 per cent. Using these percentages the test for difference in population proportions shows a difference significant at the 1 per cent (.01) level.

TABLE XXXVI

LEVEL OF EDUCATION

Education	Automated (116)		Non-automated (100)	
	Number	Per cent	Number	Per cent
High School or less	19	16.38	22	22.00
Some College	25	21.55	35	35.00
College Graduate	37	31.90	22	22.00
Some Postgrad. Education	20	17.24	14	14.00
Master's Degree	15	12.93	7	7.00

This profile analysis reveals then that the group of managers in automated firms are slightly younger, that they have slightly less years of managerial experience, and that as a group they are significantly more educated.

CHAPTER VI

AUTOMATION AND DIRECTING

Introduction

Directing is defined by Koontz and O'Donnell as: "the managerial function of guiding, overseeing, and leading people."[1] They further state:

> It (directing) is preeminently, therefore, that portion of the management process which involves personal relationships, even though... all aspects of managing must be designed to make it possible for people to work together effectively. But directing, as a function, goes particularly outside of the formal organization and the enterprise for its roots, since people are necessarily a product and a part of a culture far wider than any undertaking or its immediate industrial environment.[2]

The introduction of automated production processes may affect certain elements of the function of directing such as leadership style, motivational methods, and communications. The purpose of this chapter is to explore some of these possible effects and to present the survey results regarding automation and the directing function.

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[1] Harold Koontz and Cyril O'Donnell, eds., Management: A Book of Readings (New York: McGraw-Hill, Inc., 1968), p. 381.

[2] Ibid.

An Overview of Effects

Effect on Leadership Style

In the conventional plant the supervisor or foreman can ensure that production schedules are met by making certain that each worker performs his share of the operation at the required speed. He might display a rather authoritarian type of leadership in supervising workers. On the automated line, however, the foreman cannot influence production by driving the workers to greater speed or intensity of effort. While such methods might better be modified even in the conventional plant, they are simply meaningless on the automated line because the worker does not control the work pace, and "the speed of production is not affected by the vigor with which a button is punched or the intensity with which the machine is watched."[3]

Zalewski believes that less authoritarian attitudes will become increasingly essential to the functioning of organizations in advanced stages of automation. The reasons for this are that upper management has to rely more on specialists and because of the requirement for integrated, team operations. Also, at the lower management levels, the supervisors have to rely more on the good will of the operators

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[3]Edward B. Shils, Automation and Industrial Relations (New York: Holt, Rinehart and Winston, Inc., 1966), p. 102.

and on their knowledge of their jobs. Zalewski's conclusions are reflected in the following excerpt:

> Not only top management but supervisory personnel at all levels will face these qualitative changes in the administrative role in an automated society. A smaller, more centralized supervisory staff will necessarily resort to advice from experts whose specialized knowledge exceeds that of the supervisor in the various technical aspects of the task at hand. This fact, in itself, affects the working methods of managers and the quality of interpersonal relationships on the job. It means that supervisors will have to rely more and more on the good will of subordinates. Thus a less authoritarian attitude will become increasingly essential to the functioning of an organization ....Supervision remains essential, but it is the final results rather than detailed operations that must be supervised in advanced stages of automation.[4]

Effect on Motivation

In addition to these effects of automation on the leadership aspects of directing, it may be that worker motivation is also affected by automated production. As the working environment changes from non-automated to automated, management has to be sensitive to the psychological effects on workers. An awareness on the part of management of the factors entering into worker attitude is extremely important. This is true of course in the conventional production environment as well as in the automated plant. However, automation involves such changes in the production environment that job motivation is very likely to be affected. For

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[4]Andrzej Zalewski, "The Influence of Automation on Management," Employment Problems of Automation and Advanced Technology, ed. Jack Stieber (New York: St. Martin's Press, Inc., 1966), p. 357.

example, with reference to motivational factors Shils states: "Automation will bring out new 'slants' on the relative importance of earnings versus job satisfaction and status."[5]

A number of writers stress the importance of interpersonal relationships and job motivation. In a case study of automation in the automobile industry William Faunce found certain dysfunctions related to revised patterns of social interaction, closer worker supervision, increased feelings of tension, loss of control over the work pace, and feelings of insecurity engendered by a feeling of being divorced from the work process. Faunce reports his findings in part as follows:

> In addition to the changes in job content, there were differences between the automated plant and the plants using conventional machining techniques in patterns of social interaction on the job. As a result of increasing distance between work stations, closer attention required by the job, inability to work ahead and take a break, and machine noise, many workers in the automated plant were virtually isolated socially. Interaction occurred less frequently within smaller groups and there was less identification with a particular work group in the automatic plant. While there was less contact with other workers, the worker in the automated plant reported closer supervision by the general foreman and superintendent as well as by his foreman. The increased supervision was a result of both a decrease in the number of workers per foreman and an increase in amount of time spent by each foreman in direct supervision on the line. This increased supervision was regarded by the company as necessary because of the cost of "down time" or work stoppage in the automated departments.
>
> The decreased opportunity for social interaction and the increased supervision in the automated plant

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[5] Shils, op. cit., p. 108.

were both sources of dissatisfaction with work in this plant. Workers in the plant also reported increased feelings of tension on the job resulting primarily from the increased rate of production and the amount of attention required by the job. The loss of control of work pace and a feeling of being divorced from the work process in the sense that it was now the machine which did the work were also listed as sources of dissatisfaction with automated jobs.[6]

In another study of workers in an automatic seamless pipe mill, C. R. Walker[7] reported that workers complained of increased tension. He cites typical worker comments:

> I'd rather have to work hard for eight hours than to do nothing physical but have to be tense for eight hours, the way I do now.
>
> On my old job... my muscles got tired. I went home and rested a bit and my muscles were no longer tired. On this new automatic mill, your muscles don't get tired, but you keep on thinking, even when you go home.

In contrast with Faunce, however, Walker found that after a period of adjustment in the automated plant the workers began to demonstrate a strong feeling of belonging to a team. This was evidenced by group cohesiveness and the expressed desire to participate in joint problem solving.

In a comparison of the automated job with the non-automated job Strauss and Sayles[8] note an important difference

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[6]William A. Faunce, "The Automobile Industry: A Case Study in Automation," *Automation and Society*, eds. Howard B. Jaçobson and Joseph S. Roucek (New York: Philosophical Library, Inc., 1959), pp. 48-49.

[7]Charles R. Walker, *Modern Technology and Civilization* (New York: McGraw-Hill Book Company, Inc., 1962), pp. 204-207.

[8]George Strauss and Leonard R. Sayles, *The Human Problems of Management* (Englewood Cliffs, New Jersey: Prentice-Hall, 1960), p. 54.

in worker motivation. They point out that on the conventional assembly line there is no real incentive for workers to keep the equipment running smoothly because the more uninterruptedly the line runs, the more work the worker must do. In the automated plant, however, the operator has little to do as long as the equipment is operating smoothly. He only has to work when the equipment malfunctions. Consequently, Strauss and Sayles conclude, the worker is strongly motivated to keep the automated line in good running order.

Effect on Communication Processes

The characteristic interdependence of automated processes implies participation, and participation is facilitated through communication. Shils states that: "With automation, new channels of communications must be established."[9] He feels that in order for production engineers, technical specialists, product designers and the other employees in automated production to function as an integrated team, a more effective system of communication is necessary.[10]

Because of the requirement for the rapid flow of information, automation accentuates the need for lateral communication. As Zalewski puts it: "Rather than a vertical line on the organization chart along which orders pass from top to bottom and reports pass upward from subordinate to manager,

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[9] Shils, op. cit., p. 93.

[10] Ibid., p. 95.

a band will better express the relations and communications between the supervisor and the specialists for whose results he is responsible."[11]

The most important aspect of these possible effects of automation on the managerial function of directing is that management be aware of them, understand the possible consequences and be ready to make necessary adjustments and improvements. There is probably a tendency on the part of management to be preoccupied with the "hardware" of automation. Many writers stress the possible negative consequences of this, pointing out that attention to human factors is certainly not less important in the automated plant. Shils, for one, believes that professional managerial attention to human relationships is more important in the automated production environment: "Professional managers are more important in an automated plant than in a conventional plant.... There becomes evident a new relationship between supervisors and workers, which requires a better knowledge of human relations and organizational leadership."[12]

Survey Results: Directing

Comparison of Managerial Attitudes

The purpose of Part II of the questionnaire to individual managers was to determine the relative orientation

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[11] Zalewski, *op. cit.*, p. 358.

[12] Shils, *op. cit.*, p. 107.

of the two groups of managers toward authoritarian or participative leadership styles and to provide for a comparison of the two groups in this respect. Phatak states:

> The connotation of the terms "authoritarian management" and "participative management" and the managerial styles associated with these two management philosophies are well known. One cannot categorically classify any manager as exclusively authoritarian or participative in management style. Most managers vacillate on a continuum of managerial styles, the range spreading between authoritarian and participative managerial patterns. At the same time the managerial style(s) of a manager or groups of managers can be identified as relatively oriented toward either the so-called authoritarian management or the participative management philosophy or theory.[13]

Of the 495 managers to which the questionnaire was sent, a total of 207 managers completed the attitude questionnaire in Part II and forwarded usable data, a total response of 41.82 per cent. One-hundred-and-nine of these are managers in automated firms, and 98 are managers in non-automated firms.

Managers responded to each item in Part II on a five-point scale as follows: strongly disagree; disagree; uncertain; agree; or strongly agree. For half of the items, a high score indicates a favorable attitude toward authoritarian management concepts. For the other half of the items the scale was reversed and a low score indicates a favorable

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[13] Arvind Phatak, "Managerial Attitudes in the United States and India," The Economic and Business Bulletin (Philadelphia: Bureau of Economic and Business Research, School of Business Administration, Temple University, Summer 1969), p. 15.

attitude toward participative management concepts. Each item, in other words, was scored so that a high score (toward 5) indicates an attitude consistent with the authoritarian management style, and a low score (toward 1) indicates an attitude consistent with the participative style of management. The possible range in total score is 32 points, from 8 (extremely participative) to 40 (extremely authoritarian) with scores above 16 indicating an attitude in the authoritarian direction and scores below 16 indicating an attitude in the participative direction.

The results of the survey indicate that both groups, i.e., managers in automated and non-automated production environments, tend somewhat toward a preference for the authoritarian style--but not greatly so. The mean total questionnaire scores are 18.413 and 19.888 for the automated and non-automated groups respectively. Thus, the automated group has a lower mean total score indicating a less authoritarian tendency than the non-automated group. To determine whether or not the difference in mean total scores for the two groups is significant, an analysis of variance was conducted on the data. The analysis shows that the difference in the mean total questionnaire scores is significant at the 1 per cent (.01) level. A summary of the analysis of variance is presented in Table XXXVII.

TABLE XXXVII

ANALYSIS OF VARIANCE SUMMARY

Source	Sum of Squares	Degrees of Freedom	Mean Squares	Ratio
Production Process	112.26	1	112.26	6.913
Residual	3328.18	205	16.24	
Total	3440.44	206		

The analysis of managerial attitudes also included a comparison of the automated and non-automated groups combined with certain biographical factors, the data for which were obtained in Part I of the questionnaire to managers. The factors considered were: (1) age; (2) managerial level; (3) number of years in present position; (4) number of years with the firm; (5) number of years of managerial experience; (6) level of education; and (7) major field of study. The respondents in each of the two groups were further classified by each of these seven factors. The resulting profiles obtained are presented in Figures 5 through 11. Examination of the profiles shows that the observed range of the mean total questionnaire scores runs between 17.0 and 21.0 with three minor exceptions. Again, this indicates that both groups tend somewhat toward an authoritarian managerial attitude. However, in all categories for each biographical factor considered the mean total scores are higher for the

non-automated group than for the automated group, though in some instances the difference is small.

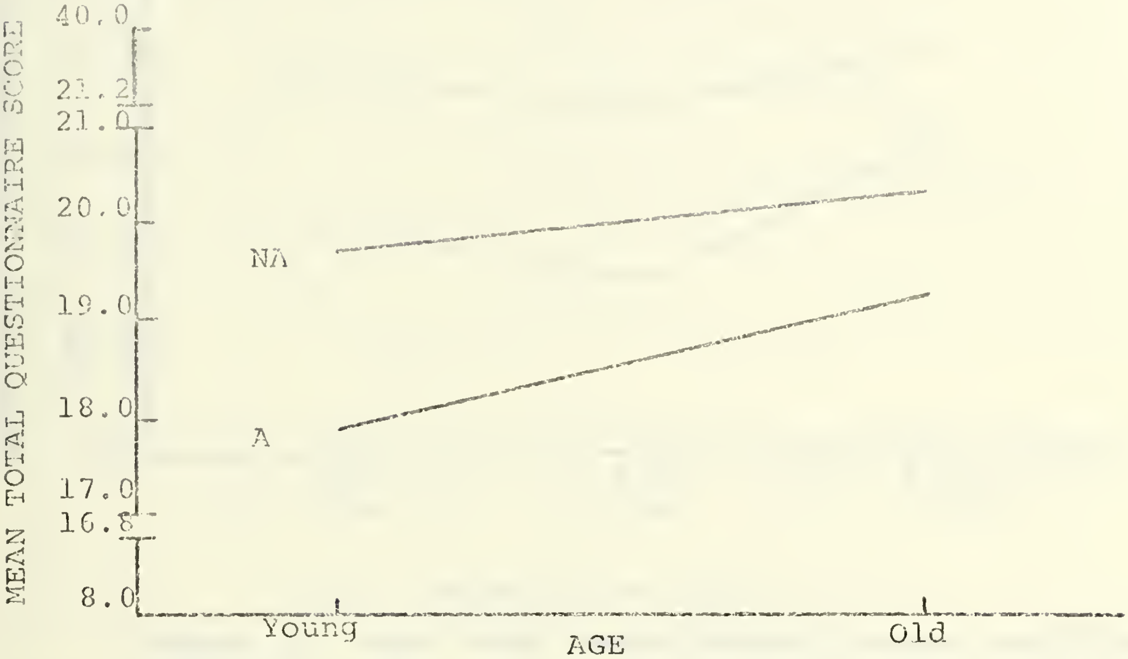

Figure 5. Mean Total Questionnaire Scores according to Production Process and Age Groups.

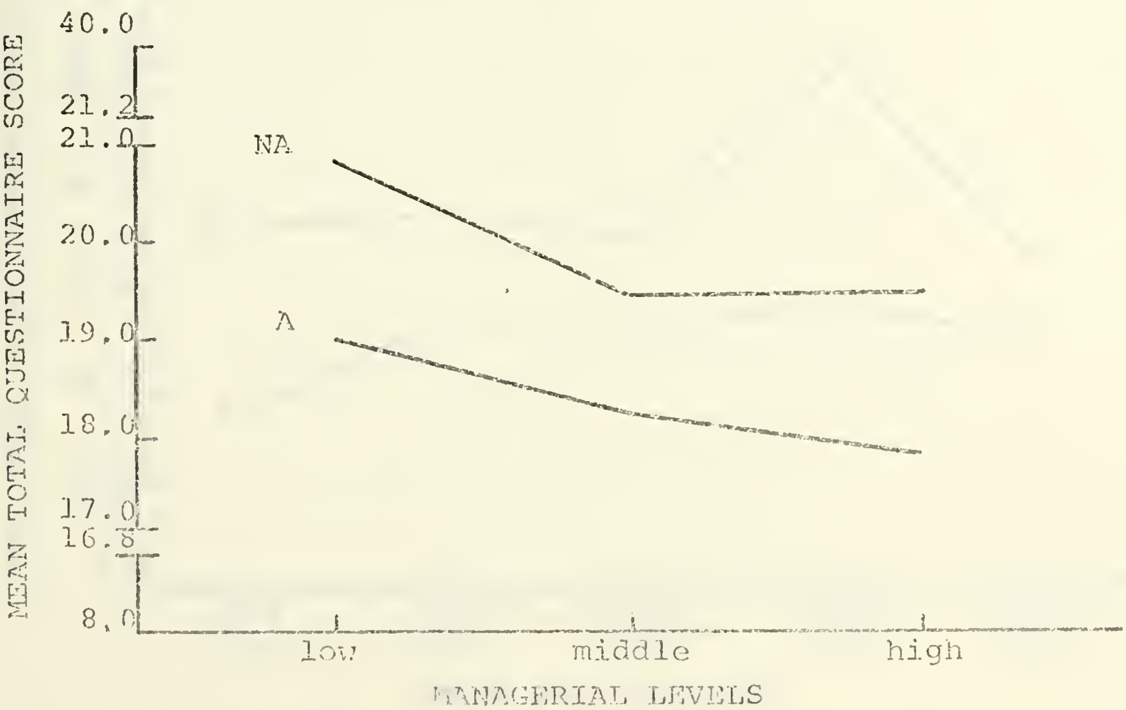

Figure 6. Mean Total Questionnaire Scores according to Production Process and Managerial Levels.

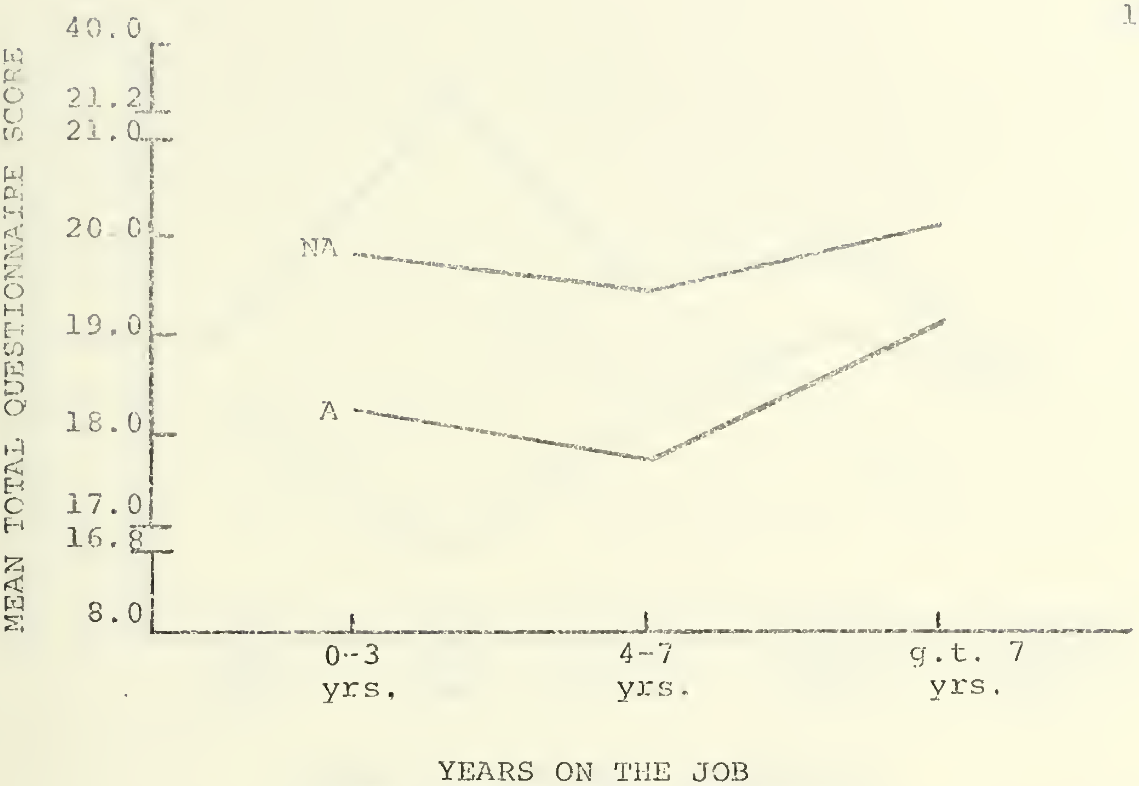

Figure 7. Mean Total Questionnaire Scores according to Production Process and Years on the Job.

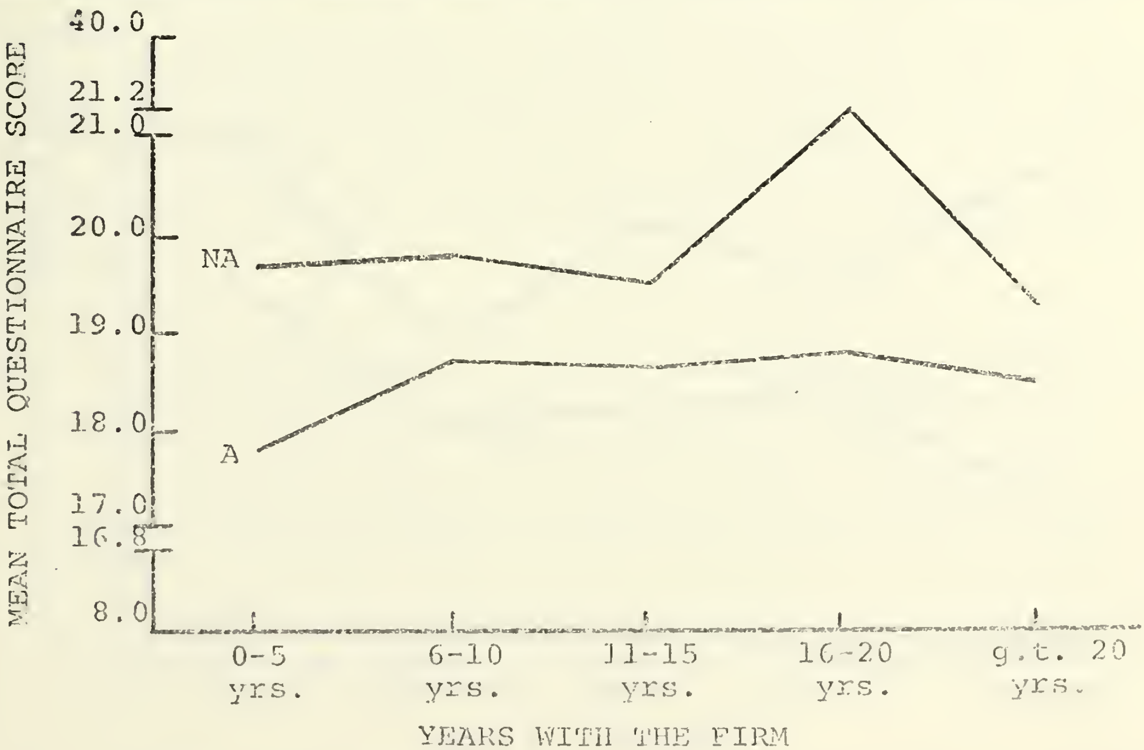

Figure 8. Mean Total Questionnaire Scores according to Production Process and Years with the Firm.

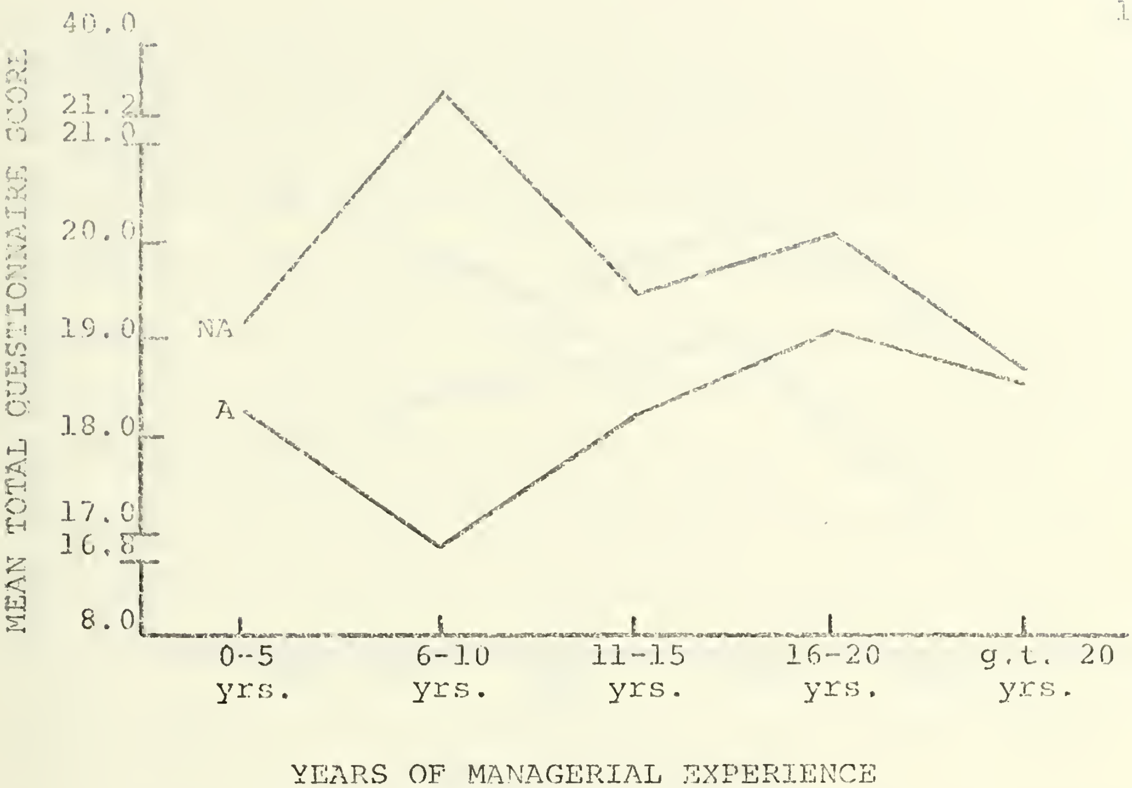

Figure 9. Mean Total Questionnaire Scores according to Production Process and Years of Managerial Experience.

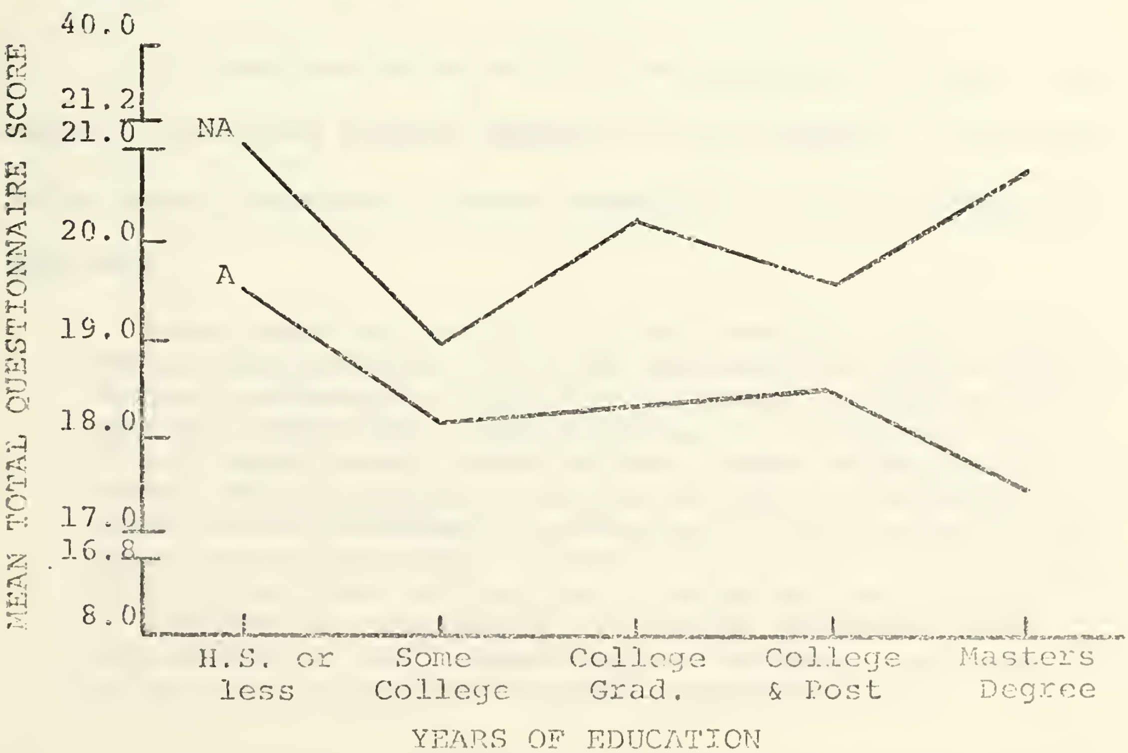

Figure 10. Mean Total Questionnaire Scores according to Production Process and Years of Education.

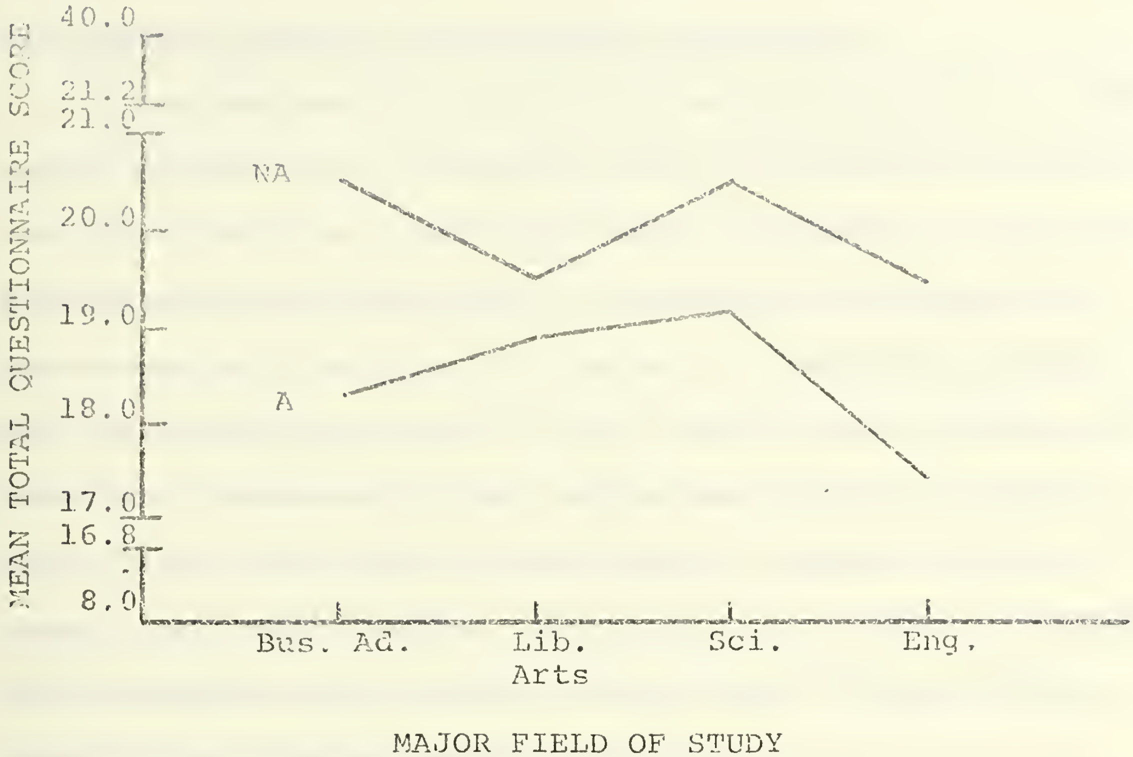

Figure 11. Mean Total Questionnaire Scores according to Production Process and Major Field of Study.

To conclude this section on managerial style, an excerpt from the Annual Report of one company in the automated group provides a good example of the participatory approach:

> Every morning at 9:30 in the Control Room, departmental foremen meet with the production Supervisor to review performance and make necessary adjustments to correct schedules...Deficiencies in the performance of any department, which affect other departments, are ironed out in preparation for the day's production. These Action Meetings, conducted within the ranks of supervisory personnel without management interference, have proved most effective in raising the standards of production efficiency. Foremen recognize the dependence of each department on others, and take pride in the problem-solving responsibility.

Management Perception of Employee Motivation

The purpose of Part III of the questionnaire to individual managers was to determine what motivational factors management believes contribute most positively to job satisfaction among employees and to compare the automated and non-automated groups in this respect. Frederick Herzberg,[14] who has devoted many years to the study of motivation, contends that management often emphasizes the wrong factors. These factors he refers to as "hygiene" factors, which, if absent, can make a worker unhappy but, according to Herzberg, their presence does not make workers want to work harder. Based on his studies Herzberg states:

> ...the factors envolved in producing job satisfaction (and motivation) are separate and distinct from the factors that lead to job dissatisfaction....
>
> Two different needs of man are involved here. One set of needs can be thought of as stemming from his animal nature--the built-in drive to avoid pain from the environment, plus all the learned drives which become conditioned to the basic biological needs. For example, hunger, a basic biological drive, makes it necessary to earn money, and then money becomes a specific drive. The other set of needs relates to that unique human characteristic, the ability to achieve and, through achievement, to experience psychological growth. The stimuli for the growth needs are tasks that induce growth; in the industrial setting, they are the job content. Contrariwise, the stimuli inducing pain-avoidance behavior are found in the job environment.
>
> The growth or motivator factors that are intrinsic to the job are: achievement, recognition for achievement,

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[14] Frederick Herzberg, "One More Time: How Do you Motivate Employees?", Harvard Business Review (January-February, 1968), pp. 53-62.

> the work itself, responsibility, and growth or advancement. The dissatisfaction-avoidance or hygiene factors that are extrinsic to the job include: company policy and administration, supervision, interpersonal relationships, working conditions, salary, status, and security.[15]

Herzberg's conclusions are based primarily on his studies of people as employees or workers. The objective in this study was to determine to what extent management's view of what the motivator factors are coincides with Herzberg's findings. Thus in Part III of the questionnaire managers were asked: "What motivational factors do you feel contribute most positively to job satisfaction among employees? Please answer this question by use of the following list of motivational factors. From the list choose the five (5) factors which you believe contribute most positively to job satisfaction and indicate your choices by check-marks." The factors listed were Herzberg's thirteen "motivator" and "hygiene" factors.

There were 208 usable responses to Part III--113 of these from managers in automated firms and 95 from managers in non-automated firms. The results for the total sample are presented in Table XXXVIII which shows how the specified factors are ranked by the total group of 208 managers. It is seen from Table XXXVIII that management considers salary to be the factor which contributes most positively to worker job satisfaction. This belief on the part of management is

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[15] Ibid., pp. 56-57.

in direct conflict with Herzberg's findings as to what factors are actually the primary cause of satisfaction and what factors are the primary cause of dissatisfaction on the job. "Salary," one of Herzberg's "hygiene" factors, was found in more instances than not to contribute to job dissatisfaction rather than to job satisfaction.[16] Table XXXVIII also shows that management places three "hygiene" factors and only two "motivator" factors in the top five. The three middle ranked factors are "motivator" factors. The "motivator" factor "responsibility" is ranked tenth in the list of thirteen, and the three lowest ranked factors are "hygiene" factors.

In Table XXXIX the survey results are shown broken down between the automated and non-automated groups. As in the result for the total sample both groups rank "salary" first as contributing most positively to job satisfaction. Four of the five highest ranked factors are the same for both groups. The automated group includes in the top five, "advancement," which is ranked sixth by the non-automated group. Also, the non-automated group includes in the top five, "working conditions," which is ranked sixth by the automated group. Both groups rank "the work itself" seventh and " "achievement" eighth. The five lowest ranked factors are the same for both groups although they are not in the same order.

In addition to the similarity between the two groups with regard to the order in which they rank the various

[16] *Ibid.*, p. 57.

factors, the differences in the percentages between the two groups are small for most of the factors. The factor showing the largest difference in percentages is "working conditions," which was included in the top five factors by 33.63 per cent of managers in the automated group and by 54.74 per cent of those in the non-automated group. The difference in these two proportions is significant at the 1 per cent (.01) level. The differences for the factors "company policy and administration," "opportunity for personal growth," and "salary" are all just significant at the 10 per cent (.10) level.

The automated group includes three "motivator" factors ("recognition for achievement," "opportunity for personal growth," and "advancement") in the top five. The non-automated group includes only two "motivator" factors ("recognition for achievement" and "opportunity for personal growth") in the top five, although the sixth ranked factor, "advancement," is a "motivator" factor. The factors "the work itself" and "achievement" ranked seventh and eighth, respectively, by both groups are "motivator" factors. Four of the five factors ranked lowest by both groups are "hygiene" factors--the exception being the "motivator" factor "responsibility."

Thus, the two groups of managers are much more similar than dissimilar in their beliefs about what factors are more important in promoting job satisfaction. Their beliefs, however, are not consistent with research findings as to what

factors are actually the primary cause of worker satisfaction and which ones are the primary cause of dissatisfaction.

TABLE XXXVIII

RANKING ASSIGNED TO MOTIVATION FACTORS BY MANAGEMENT

Factor	Number (208)	Per cent
Salary	168	80.77
Recognition for achievement	156	75.00
Security	109	52.40
Opportunity for personal growth	102	49.04
Working conditions	90	43.27
Advancement	81	38.94
The work itself	70	33.65
Achievement	62	29.81
Relationships with other employees	46	22.12
Responsibility	40	19.23
Company policy and administration	40	19.23
Supervision	39	18.75
Status	32	15.38

TABLE XXXIX

RANKING ASSIGNED TO MOTIVATION FACTORS BY THE AUTOMATED AND NON-AUTOMATED GROUPS

Automated Group (113)		Non-automated Group (95)	
Factor	Per cent	Factor	Per cent
Salary	84.96	Salary	75.79
Recognition	76.99	Recognition	72.63
Personal growth	54.87	Work conditions	54.74
Security	51.33	Security	53.68
Advancement	38.94	Personal growth	42.11
Work conditions	33.63	Advancement	38.95
Work itself	32.74	Work itself	34.74
Achievement	30.09	Achievement	29.47
		Company policy	24.21
Relationships with other employees	23.89	Supervision	21.05
Responsibility	21.24		
Supervision	16.81	Relationships with other employees	20.00
Status	15.93	Responsibility	16.84
Company policy	15.04	Status	14.74

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

It was stated in Chapter I that the broad hypothesis underlying this study is that the introduction of automated production systems will affect the responsibilities, roles and activities of management. The purpose of the study has been the investigation of certain effects of production automation on the process of management in terms of the managerial functions of planning, controlling, organizing, staffing and directing.

The study was introduced by a review of the relevant literature. It was seen that there has not been a standardized, uniformly accepted definition of automation. The literature does reveal, however, that there is wide agreement that the concepts of continuous flow and closed-loop automatic control are essential to the full automation of manufacturing and processing systems.

Based on the literature, the history of automation was traced from three standpoints: (1) the evolution of control devices; (2) the evolution of continuous flow of assembly and transfer operations; and (3) the evolution of data processing automation. It was seen that in some respects the

principles of automation can be traced to ancient origins. In the section concerning the state-of-the-art of automation, however, it was noted that while there may be basically nothing new about automation in so far as concepts are concerned, the modern equipment and devices which make automatic control and handling more feasible and the extensiveness of the applications of automation are new. This section also included an explanation of the distinction between automation in process industries and the automation of discreet production. The section concluded with a presentation of examples of current automation applications and installations.

The final section in the review of the literature chapter traced the development of professional management in relation to technological evolution.

The four chapters following the review of the literature constitute the report of the primary research effort and addressed themselves to the effects of production automation on the managerial functions of planning, controlling, organizing and staffing, and directing. Each chapter contained an overview of effects based on the literature and previous studies and a report of the survey results pertaining to the managerial function being investigated.

In the chapter dealing with the effects of automation on the planning function it was first suggested that planning is the managerial function most affected by automation. The following section included treatment of:

1. The increased criticality of planning resulting from automating production

2. The effect of automation on the managerial planning horizon

3. The effect of integrated production on management philosophy

4. The increased importance of business forecasting under automated production

5. The effects of automated production on the decision environment

The succeeding section reported the survey results pertaining to planning. The sub-functions, elements or aspects of planning to which the survey addressed itself were:

1. Analysis and comparison of the automated and non-automated groups with regard to the existence of written corporate plans

2. Analysis and comparison in terms of the length of future planning periods

3. Analysis and comparison with regard to the existence of written statements of objectives and goals

4. Analysis and comparison of business forecasting practices

5. Analysis and comparison in terms of planning and decision-making techniques employed

The final section of this chapter dealt with indicators of the impact of production automation on managerial planning.

The second of the four primary research chapters was concerned with the effects of automation on the control function. The first section of this chapter discussed and established that the most prevalent reasons for automating production are based on control factors--the singlemost

important reason being the desire to reduce costs. The following section included discussions of:

1. The integration of control

2. The requirement for diminished response times in the automated production environment

3. The effects of production automation on the capacity to control

The remainder of the chapter was devoted to reporting the survey results pertaining to the control function. The elements of control to which the survey addressed itself were:

1. Analysis and comparison of the automated and non-automated groups in terms of the criteria used for measuring organizational performance

2. Analysis and comparison of the types of management information systems installed in the automated and non-automated companies

The next research chapter was concerned with the effects of automation on the organizing and staffing functions. The first section explained the close relationship between the organizing and staffing functions. The following section treated:

1. The effects of automation on management structure

2. The increase in the number and importance of technical and other special support groups accompanying automation

3. The redefinition of management credentials as production becomes more automated

4. Effects of automation on management of the work force

5. Effects of automation on wage administration

The remainder of the chapter was devoted to reporting the survey results pertaining to the organizing and staffing functions. The elements to which this part of the survey addressed itself were:

1. Wage plan patterns in the automated and non-automated groups

2. Production work force skill requirements

3. Analysis and comparison of management profiles for the automated and non-automated groups

The final research chapter was concerned with the effects of automation on the directing function. The first section discussed the unique nature of the directing function in that it is preeminently that part of the management process which involves interpersonal relationships. The succeeding section treated:

1. The effects of automation on leadership style

2. The effects of automation on worker motivation

3. The effects of automation on communication processes

The remainder of the chapter was devoted to reporting the survey results pertaining to the directing function. This part of the survey addressed itself to:

1. Analysis and comparison of managerial leadership styles in the automated and non-automated groups

2. Analysis of management perception of employee motivation and a comparison of the automated and non-automated groups in this respect

Conclusions

The findings and conclusions presented here are based on the survey results which were reported in the four research chapters. Most of the conclusions rest on statistical comparisons of the automated and non-automated groups of companies.

Questions 3a, 3b, 4a, 4b, 5 and 6 of the questionnaire to companies were designed to determine the effects of automation on certain aspects of managerial planning. First, based on the response to Question 3a, a comparison of the automated and non-automated groups was made in terms of the relative criticality of advance planning as reflected by the existence of written corporate plans. Statistical analysis of the data showed that a significantly higher proportion of the automated companies have written plans. The conclusion drawn from this is that the management of automated companies _does_ experience a more critical need for formalized advance planning. It was also found, however, in response to Question 3b, that considering companies which do have formalized corporate plans, there are _not_ significant differences between the automated and non-automated groups with regard to the amount of multi-year and long-range planning.

The data obtained in response to Question 4a were analyzed statistically to determine if there were significant differences between the two groups in terms of the existence of written statements of objectives and goals. From this

analysis it may be concluded that the management of automated companies attach a greater importance to advance planning as reflected by the significantly higher proportion of automated companies having written statements of objectives and goals.

The purpose of Question 5 was to obtain information enabling a comparison of the automated and non-automated groups with regard to: (1) the extent of business forecasting activities; (2) the frequency with which forecasts are made; and (3) the length of periods for which forecasts are made. The forecast types considered were sales forecasts, production forecasts, profit forecasts, manpower forecasts, financial requirements, equipment requirements, facility or plant requirements, and technological forecasts. Statistical analysis showed that a significantly higher proportion of automated companies make forecasts in each of the eight specified areas. It is therefore concluded that automation does have an effect on whether or not companies engage in forecasting. The analysis in terms of the frequency with which forecasts are made indicated that, with the exception of manpower forecasts, the automated companies perform forecasts more frequently than the non-automated firms. Furthermore, based on an analysis of the length of periods for which the various types of forecasts are made it may be concluded that the automated group tends to forecast further into the future than does the non-automated group.

The response to Question 6 showed that very few companies in either the automated or non-automated groups make use of certain of the quantitative planning and decision-making techniques specified. Based on a non-statistical comparison, however, it is reasonable to conclude that more of the automated companies employ advanced planning and decision-making techniques.

Question 7 of the questionnaire to companies was designed to determine if there are differences between the automated and non-automated groups in the importance assigned by management to certain measures of organizational performance. It was found that the two groups were much more similar than dissimilar in the order of importance in which they ranked the specified performance measures. It is therefore concluded that automation has only minor effects on the relative importance assigned by management to the various criteria for measuring and evaluating organizational performance.

Another indication of the effect of automation on management in terms of the control function is the relative complexity of the management information system. The purpose of Question 8 was to provide for a comparison of the automated and non-automated groups is this respect. Based on statistical analysis of the results it is possible to conclude that the proportion of automated companies having computer-based management information systems is significantly

higher than the proportion of non-automated companies having such systems.

Questions 9 and 10 of the questionnaire to companies and three of the questions in Part I of the questionnaire to individual managers were designed to evaluate the effects of automation on certain aspects of the organizing and staffing functions. Based on statistical analysis of the response to Question 9 the conclusion is that at present there are not significant discernible differences in the pattern of wage plans in use for production workers in automated versus non-automated firms.

The response to Question 10 indicated that the percentage of skilled and semi-skilled production workers is considerably higher for the automated group than for the non-automated group. The analysis was based, however, on two small sub-groups. Consequently, the evidence is considered insufficient to draw a general conclusion regarding the effect of automation on skill requirements.

Part I of the questionnaire to individual managers was designed, in part, to obtain data enabling a comparison of the management profile in the automated production environment with the management profile in the non-automated production environment. The factors considered in the comparison were age, number of years of managerial experience and level of education. From the profile analysis it is concluded that the managers in the automated group of firms

are slightly younger, that they have slightly fewer years of managerial experience, and that as a group they are significantly more educated.

The questionnaire to individual managers was designed primarily for the purpose of investigating certain effects of automation on the directing function. Specifically, the purpose of Part II was to determine the relative orientation of the two groups of managers toward authoritarian or participative leadership styles and to provide for a comparison of the two groups in this respect. The survey results indicated that both groups, i.e., managers in automated and non-automated production environments, tend somewhat toward a preference for the authoritarian style. The automated group, however, exhibited a less authoritarian tendency than the non-automated group. Statistical analysis of the data showed the non-automated group to be significantly more authoritarian in managerial attitude.

The purpose of Part III was to determine what motivational factors management believes contribute most positively to job satisfaction among employees and to compare the automated and non-automated groups in this respect. Considering the response for the total sample of managers it was seen that management's beliefs are not consistent with previous research findings as to what factors are actually the primary cause of worker satisfaction and which ones are the primary cause of dissatisfaction. The managers ranked

more "hygiene" or "maintenance" factors than "motivator" factors in the five most important. In comparing the responses of the automated and non-automated groups it was found that the two groups were quite similar with regard to the order in which they ranked the specified factors. One conclusion drawn from these results is that there are only minor differences between the two groups in their beliefs about what factors are more important in promoting job satisfaction. It is further concluded that management may be emphasizing factors which do not necessarily motivate employees and contribute to job satisfaction.

Areas for Further Research

There are two specific suggested areas for further research, both of them arising from limitations of this study. First, because of the differences between various automated production processes, the effects of automation on management may vary from industry to industry. Therefore, an important area for further research would be the study of effects of production automation on management within given industries. Secondly, this study does not account for the possible effects of company size on management for the functions, sub-functions and elements investigated. There remains a need to separate and measure the effects of size. This too is suggested as an area for further research.

APPENDICES

APPENDIX A

Letterhead: The University of Georgia
College of Business Administration
Athens, Georgia 30601

January 22, 1970

Dear Sir:

I am a candidate for the Ph.D. degree in Business Administration at the University of Georgia.

Your help is requested in an intensive study of "Management and Technology." It will take a few minutes of your time, but these minutes collectively will provide the data for the most important part of my doctoral dissertation. The primary objective of the study is to contribute to a better understanding of this increasingly important topic.

Your answers to the enclosed questions will be kept in confidence and will appear only in unidentified or statistical summary form with those of other companies. No one but me will see your returned questionnaire.

It will be helpful to me if you do provide your company name in question #1 for reasons of product classification; however, if you prefer not to indicate company name, please leave it blank and complete the remainder of the questionnaire.

Please use the enclosed envelope to return the questionnaire directly to me.

Thank you for your help.

Sincerely,

John E. Wildman

APPENDIX B

Letterhead: The University of Georgia
College of Business Administration
Athens, Georgia 30601

January 22, 1970

Dear Sir:

I am a candidate for the Ph.D. degree in Business Administration at the University of Georgia.

Your help is requested in an intensive study of "Management and Technology." It will take a few minutes of your time, but these minutes collectively will provide the data for the most important part of my doctoral dissertation. The primary objective of the study is to contribute to a better understanding of this increasingly important topic.

Your answers to the enclosed questions will be kept in confidence and will appear only in statistical summary form with those of other managers. No reference to an individual manager or an individual company will be made. No one but me will see your returned questionnaire.

It will be helpful to me if you do provide the name of your company in question #1 for reasons of product classification. However, if you prefer not to indicate company name, please leave it blank and complete the remainder of the questionnaire.

Please use the enclosed envelope to return the questionnaire directly to me.

Thank you for your help.

Sincerely,

John E. Wildman

APPENDIX C

EXAMPLES OF CORPORATE OBJECTIVES FROM THE AUTOMATED GROUP

Company A

OVERALL OBJECTIVES

1. To develop earnings per share that can be sustained over the long range and can be increased progressively without erratic swings during various cyclical periods.
   a. To develop a reasonable and constructive market evaluation of our stock.
2. To be strong enough and competent enough in each of our chosen fields of business that we are not at a competitive disadvantage in the market place.
3. To provide a business atmosphere within which each employee can maximize his or her individual potential for growth and advancement.
4. To accept the responsibility and to exercise the opportunity to be a constructive force in the nation and in our communities in the development of an improved social structure.

Company B

CORPORATE OBJECTIVES

1. (Company B) will conduct its business in a manner which upholds its reputation for integrity, quality, reliability, and special capabilities; maximizes the value of the stockholders' investment; provides opportunities for all its employees to grow, perform, and achieve financial security.
2. (Company B) will plan and achieve a continued profit growth as measured by return on investment and earnings per share.
3. (Company B) will carry on appropriately balanced, diversified, growing, and profitable businesses in...
4. (Company B) will comply with applicable laws and regulations in the equal employment opportunity field. It will not discriminate against any employee or applicant for employment because of race, religion, color, national origin, age or sex.
5. (Company B) will be a market-oriented company:
   - (a) ascertaining and anticipating the needs of present and future markets it can serve;
   - (b) acquiring market positions, including consumer markets, where feasible and desirable in preference to selling raw or semi-finished materials or basic commodities;

(c) achieving product and service pre-eminence in chosen markets;

(d) becoming completely deployed toward markets basing organization, capital investment, product development on response to market dynamics;

(e) withdrawing from markets showing continued uncorrectable low return on investment.

6. (Company B) will achieve highly efficient manufacturing capability in its major product lines; will keep its facilties in superior operating condition; will maintain in its operating areas suitable environmental quality, and will meet, and when possible exceed, in both letter and spirit, all environmental standards.

7. (Company B) will achieve growth in the following ways:

(a) By continual increase (including geographical expansion) in percentage share of those present markets and products which have the greatest profit and growth potential;

(b) By entry into related new markets and products, based upon exploitation of present market position, manufacturing capabilities, and existing or newly developed technology;

(c) By licensing, export sales, and limited equity investments abroad;

(d) By acquisition of businesses conforming to other objectives of this plan, meeting the following criteria:

- engaged in manufacture of present products, or related new markets and products;
- strengthen (Company B's) market, management, manufacturing, raw material or technical position;
- bring financial advantage to (Company B).

Company C

STATEMENT OF OBJECTIVES

1. To make a profit by serving primarily the ( ) industries through engineering, manufacture, and marketing of high-quality products.
2. To maintain a sound financial position to provide for growth, diversification, and research as well as to insure economic stability, security, and opportunity for our stockholders and employees. To share profits with employees as an incentive for improved performance, while paying our stockholders a good return on their investment. To contribute a share of the profits through the (Company C) Foundation for educational, religious, and charitable purposes for use primarily in our plant communities, but also throughout the United States.
3. To administer the resources and facilities of the Company effectively and harmoniously by:
   a. Maintaining a sound organization structure through which management can most effectively direct and control the enterprise;
   b. Providing the motivation and opportunity to employees to develop their skills and abilities to perform their present jobs better and to become prepared for advancement to better jobs;

c. Stimulating the initiative of employees to suggest, plan, develop, and promote improvements in methods, systems, procedures, products, and facilities, to keep informed of the best industrial practices, and to insure that outmoded procedures and uneconomical methods are abolished;

d. Conducting the day-to-day business of the Company on an efficient and effective basis that will provide both short-range and long-range profitable operations;

e. Maintaining sound personnel policies and practices so that employees are treated fairly and justly in accordance with our respect for the dignity of individuals and so that they aid in and are consistent with attainment of our commercial and financial objectives; and

f. Keeping employees, stockholders, customers, suppliers, and our public continuously informed of our objectives, plans, and accomplishments.

Company D

CORPORATE OBJECTIVES

OBJECTIVE -- To be the outstanding (   ) organization in the world.

OBJECTIVE -- To discover new solutions to our customers' problems and to use this knowledge to develop new products.

OBJECTIVE -- To make a profit sufficient to create and attract required capital to support our growth.

OBJECTIVE -- To attract, develop, and retain highly competent, enthusiastic people who make it possible to realize the other objectives.

OBJECTIVE -- To participate as a corporation and to encourage participation by individuals in the life of our communities, with the intent to assume our fair share of civic responsibilities.

Company E

(COMPANY E'S) CORPORATE PURPOSE

(Company E) will meet with integrity its responsibilities to shareholders, customers, employees, suppliers, government and society.

(Company E) intends to rank among the highest 20 per cent of comparable U.S. companies in terms of earnings growth and return on shareholders equity, thereby enhancing the value of its stock. In sales volume, (Company E's) objective is to be one of the top 500 manufacturing companies in the U.S.

The company intends to continue and expand its diversified basis of operations within its areas of competence. Entry will be made into selected new markets and products. (Company E) will continue to develop its international operations in areas of opportunity. It will discontinue operations that do not produce satisfactory long-term returns on committed resources.

(Company E) will manage its affairs with excellence. It will develop and employ strategic planning as a framework for achieving its objectives. Plans will include courses of action to be taken and timetables for accomplishment.

(Company E) intends to broaden the market for its New York Stock Exchange listed stock and to retain its present independent identity.

Company F

(COMPANY F) CORPORATE OBJECTIVES

(Company F's) objectives are designed to generate enthusiasm, involvement, productivity, and increased profits throughout the entire corporation. The (Company F) Corporate Objectives are:

(a) To build an integrated technology company;

(b) To increase earnings per share at a minimum rate of 15% annually;

(c) To increase internal sales growth, exclusive of acquisitions, at a minimum rate of 10% annually;

(d) To maintain an after-tax return on new investment of 15%;

(e) To insure the total involvement and motivation of key personnel.

Each of these corporate objectives is important in its own right, yet each complements the other.

First, (Company F) will continue to build an integrated technology company. Our commitment in expanding the integrated technology concept will permit the corporation not only to serve a growing and expanding series of interrelated markets but it will also generate capital to enable us to expand research and development activities, to invest in new ventures, and introduce new products.

We believe a combination of capable, highly motivated people coupled with in-depth planning and review at all management levels will assure us of reaching our earnings per share objectives.

Third, (Company F) projects an internal sales growth, exclusive of acquisitions, at a minimum rate of 10 per cent per year. (Company F) is constantly reviewing its sales efforts, developing and looking for new products and markets and making a determined effort to replace low gross profit products with higher gross profit items.

Fourth, (Company F) plans for an after-tax return on investment of 15% as a minimum for new capital ventures. Constant appraisal of present markets, margins and product obsolescence and an awareness of new products and new markets determine where (Company F) invests to maximize future earnings.

Finally, and most important, is the active participation in the corporation by all supervisory people and employees in establishing corporate and individual goals. Measurable budgets, standards and objectives have been established for all members of (Company F), and individual performance is evaluated to determine accomplishment and reward.

Company G

GENERAL CORPORATE OBJECTIVES

A. To contribute toward a better life for our employees and the families.

B. Provide maximum security and a fair return for all who have invested in our company either directly or indirectly.

C. To be a good citizen and of service to our community, state and nation.

D. To provide our customers with increasingly better quality products and better service at competitive price and always treat them fairly.

Company H

1. To manage our business with the primary objective of making a contribution to society. Business can be one of the most effective vehicles through which man serves society. Thus, any service we perform should be oriented toward the public welfare, and any product we manufacture should be designed to be the best possible product in its price class.
2. To recognize the dignity and personal worth of every individual. All employees should have the opportunity to share in the company's success, for each of them helps to make it possible. Every individual deserves job security in accordance with his performance on the job and the personal satisfaction of being commended for a job well done. The objective is not simply to make the organization more efficient--although that will certainly be one result--but to emphasize beyond any possible doubt that human labor is not a commodity to be bought and sold in the marketplace.
3. To recognize our responsibility to society in general. We are all indebted to those who developed and to those who preserve our system of government and for the freedom to carry on our business; to our schools and universities for pushing forward the frontiers of knowledge; and to our religious organizations for their moral training.

We must support these institutions of our society with all the energy and strength at our command if we wish to preserve our freedom and individual liberty.

4. <u>To develop and encourage a better understanding of the nature of profit</u>. Profit is the monetary measure of the contribution of the business to society. It is the difference between the value of goods and services we give to society and the remuneration obtained for them. It is our insurance that the business will continue to grow and flourish, meeting all of its obligations to customers, employees and the general public. It provides the stockholders with a fair return and encourages further investment. Profit, in short, is not the proper <u>end</u> of business; it is merely the <u>means</u> that makes the achievement of the proper ends possible.

APPENDIX D

EXAMPLES OF CORPORATE OBJECTIVES FROM THE NON-AUTOMATED GROUP

Company I

STATEMENT OF OBJECTIVES

(Company I) Objectives Related to Shareholders

(Company I) will strive to carefully plan, organize, coordinate, and control its available resources of time, space, material, money and people to insure their most productive and effective use.

(Company I) will strive to create and keep satisfied customers.

(Company I) will strive to expand the use of its products domestically and internationally into every industry where needs for them exist or can be created.

(Company I) will strive to constantly evaluate the strengths and weaknesses of every facet of its organization, giving particular attention to the qualifications, growth, and development of people.

(Company I) will strive to promote the confidence and respect of customers, employees, suppliers, shareholders,

and the general public by exercising the highest standards of honesty, fair play and ethical conduct.

(Company I) will strive to produce profit results and increase equity ownership values consistent with company objectives and competitive forces at work in our economy.

<u>(Company I) Objectives Related to Employees</u>

(Company I) will strive to recognize the personal goals of each individual in the company seeking means to harmonize them with company objectives.

(Company I) will strive to develop a climate for individual achievement compatible with company objectives by encouraging creativity, initiative, individuality, judgment, and individual development and growth.

(Company I) will strive to base employment and treatment of employees upon individual qualifications with due consideration for length of service. Qualification means ability, actual and potential, and has no reference to religion, birthplace, sex, race or color.

(Company I) will strive to provide opportunities for advancement, full use of abilities and skills, and recognition and reward for satisfactory or outstanding performance.

(Company I) will strive to encourage teamwork, develop employee security and give all employees a sense of belonging.

(Company I) Objectives Related to Customers

(Company I) will strive to use its resources effectively to provide customers with high quality, dependable products used to ( ) and develop or acquire other products or enterprises which will enhance the service of the company to its customers.

(Company I) will strive to provide delivery of products promptly according to customer requirements.

(Company I) will strive to adequately and promptly provide customer requirements for maintenance, repair and technical advice related to its products and their application.

(Company I) will strive to treat customers fairly, courteously, and respectfully.

(Company I) will strive to assure complete customer satisfaction with products and service by striving for excellence in every area of its operation.

(Company I) Objectives Related to the Public

(Company I) will strive to participate in community, state and national affairs.

(Company I) will strive to participate in programs compatible with company beliefs which promote individual freedom, development, responsibility, self-help, and personal accomplishment.

(Company I) will strive to prevent encroachment upon or suppression of basic human rights or the Free Enterprise system.

(Company I) will strive to interpret its actions promptly and accurately to the public.

Company J

Purpose:

(Company J) is in business for the purpose of earning a fair and adequate profit as a means in accomplishing the following:

1. To accept and fulfill its responsibilities in perpetuating the private enterprise system, recognizing that it is this system of government which has given it this opportunity in the first place.
2. To perpetuate the Company for the benefit of all who depend upon it.
3. To compensate its investors for risking their capital in its behalf.

The Company intends to accomplish this purpose by:

1. Participating actively in the affairs of the community, the state, and the nation to make the independent sector of the society in which we live more effective in meeting the needs of the people rather than depending on an inefficient, dictatorial, centralized federal government to do so.
2. Creating a dynamic growth Company with (   ) as the nucleus of its growth.
3. Producing a superior product value at a price which the mass market can afford to pay through

the greatest use of mass marketing and production techniques.

4. Selling customer service and assistance as much as product, since individual products come and go, but a deserved reputation for top service will provide continuing customers for all products we may offer.
5. Working toward full employment for the employees of the Company and offering competitive wages and benefits.
6. Acting in a fair and honest manner in all our dealings within and without the Company, cultivating an image which truthfully reflects our convictions and intentions throughout the society in which we live and in the minds of all who come in contact with it.
7. To extend our loyalty to all those customers, suppliers, and professionals who deserve and earn it.
8. Helping our customers earn fair and adequate profits from their resale of our products, realizing that our profits ultimately depend upon the profit of our customers.
9. Developing people to their maximum capabilities for the benefit of the Company as a whole, and

even more important, for their own benefit and personal gratification of accomplishment.

10. Recognizing the permanence of change and conducting our affairs in such a manner to make change our ally rather than our enemy.

BIBLIOGRAPHY

BOOKS

Amber, G. H., and Amber, P. S. Anatomy of Automation. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962.

Bolz, Roger W. Understanding Automation: Elements for Managers. Cleveland, Ohio: The Penton Publishing Company, 1966.

Booth, Andrew D., ed. Progress in Automation. London: Butterworths Scientific Publications, 1960.

Bowen, Howard R., and Mangum, Garth L., eds. Automation and Economic Progress. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966.

Bright, James R. Automation and Management. Norwood, Massachusetts: The Plimpton Press, 1958.

Buckingham, Walter S., Jr. Automation: Its Impact on Business and People. New York: Harper and Row, 1963.

Chruden, Herbert J., and Sherman, Arthur W., Jr. Personnel Management. Cincinnati: Southwestern Publishing Company, 1963.

Davis, Ralph C. Industrial Organization and Management. New York: Harper and Brothers, 1957.

Dearden, John, and McFarlan, F. Warren. Management Information Systems: Text and Cases. Homewood, Illinois: Richard D. Irwin, Inc., 1966.

Diebold, John. Automation: The Advent of the Automatic Factory. New York: D. Van Nostrand Co., 1952.

________. Beyond Automation. New York: McGraw-Hill Book Company, 1964.

Dixon, Wilfrid J., and Massey, Frank J. Introduction to Statistical Analysis. New York: McGraw-Hill Book Company, Inc., 1957.

Dunlop, John T., ed. Automation and Technological Change. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962.

Fayol, Henri. General and Industrial Administration. New York: Pitman Publishing Corporation, 1949.

Francois, William. Automation: Industrialization Comes of Age. New York: The Mcmillan Company, 1964.

Jacobowitz, Henry. Electronic Computers. New York: Doubleday and Company, Inc., 1963.

Jacobson, Howard B., and Roucek, Joseph S., eds. Automation and Society. New York: Philosophical Library, 1959.

Jaffe, Abram J., and Froomkin, Joseph. Technology and Jobs. New York: Frederick A. Praeger, Inc., 1968.

June, Stephen A., and Others. The Automatic Factory. Pittsburgh: Instruments Publishing Company, 1955.

Koontz, Harold, and O'Donnell, Cyril, eds. Management: A Book of Readings. New York: McGraw-Hill, Inc., 1968.

Lossiyevskii, V. L., ed. The Automation of Production Processes. New York: The Macmillan Company, 1963.

Mee, John F. Management Thought in a Dynamic Economy. New York: New York University Press, 1963.

Michael, Donald N. Cybernation: The Silent Conquest. Santa Barbara: Center for the Study of Democratic Institutions, 1962.

Ostle, Bernard. Statistics in Research. Ames, Iowa: The Iowa State University Press, 1963.

Rosenberg, Jerry M. Automation, Manpower, and Education. New York: Random House, 1966.

Rosove, Perry E. Developing Computer-Based Information Systems. New York: John Wiley and Sons, Inc., 1968.

Scott, Ellis L., and Bolz, Roger W., eds. Automation and Society. Athens, Georgia: The Center for the Study of Automation and Society, 1969.

Shils, Edward B. Automation and Industrial Relations. New York: Holt, Rinehart and Winston, Inc., 1966.

Silberman, Charles E. The Myths of Automation. New York: Harper & Row, 1966.

Simon, Herbert A. The Shape of Automation for Men and Management. New York: Harper & Row, 1965.

Stieber, Jack, ed. Employment Problems of Automation and Advanced Technology. New York: St. Martin's Press, Inc., 1966.

Strauss, George, and Sayles, Leonard R. The Human Problems of Management. Englewood Cliffs, New Jersey: Prentice-Hall, 1960.

Taylor, George W., and Shils, Edward B., eds. Industrial Relations in the 1960's: Problems and Prospects. Philadelphia: University of Pennsylvania, 1961.

Thompson, Howard A. Joint Man/Machine Decisions. Cleveland: Systems and Procedures Association, 1965.

Walker, Charles R. Modern Technology and Civilization. New York: McGraw-Hill Book Company, Inc., 1962.

Wiener, Norbert. Cybernetics. New York: John Wiley and Sons, Inc., 1948.

PAMPHLETS AND REPORTS

American Management Association. Keeping Pace with Automation. New York: American Management Association, 1956. (Special Report No. 7.)

Aronson, Robert L. Jobs, Wages, and Changing Technology. Ithaca, New York: New York State School of Industrial and Labor Relations, 1965.

Arthur D. Little, Inc. Analysis of Automation Potential by Means of Unit Operations. (Report to Department of Labor, Office of Manpower, Automation and Training.) Arthur D. Little, Inc., 1965.

Burack, Elmer H., and McNichols, Thomas J. Management and Automation Research Project: Final Report. Chicago: Illinois Institute of Technology, 1968.

Market Research Department of Automation Magazine. 1968 Automation Trends Survey and Forecast. Cleveland: Automation Magazine, 1968.

Organization for Economic Co-operation and Development. Manpower Aspects of Automation and Technological Change. (A report on European Conference of February, 1966.) Paris: O.E.C.D., 1966.

Organization for Economic Co-operation and Development. Report on the "North American Joint Conference on the Requirements of Automated Jobs and their Policy Implications" held in Washington, D. C. on December 8-10, 1964. Paris: O.E.C.D., 1965.

Roberts, Richard S., Jr. Management Decisions to Automate. Menlo Park, California: Stanford Research Institute, 1964.

Rowe, H. Douglass. Automation to Date. New York: American Management Association. (Manufacturing Series No. 209.)

ARTICLES

Ashburn, Anderson. "Automation--Its Development in Metalworking," Mechanical Engineering, November, 1955, 958-963.

"Automatic Assembly," Automation, December, 1969, 7.

"Automatic Contour Control," American Machinist, July 10, 1950, 75.

"Automatic Electrical Sizing Equipment for Bryant Chucking Grinder," American Machinist, April 23, 1931, 664-665.

"Automatic Jigs that Have Cut Automobile Costs," Machinery, August, 1931, 897-902.

Bright, James R. "Does Automation Raise Skill Requirements," Harvard Business Review, July-August, 1958, 85-98.

Drucker, Peter F. "The Next Decade in Management," Dun's Review and Modern Industry, December, 1959, 60-61.

"Electric Motors Automatically Assembled," Automation, December, 1969, 156.

"Engine Blocks Completely Machined in One Multiple Tool Operation," Automotive Industries, February 12, 1925, 272-275.

Herzberg, Frederick. "One More Time: How Do You Motivate Employees," Harvard Business Review, January-February, 1968, 53-62.

Hurd, Cuthbert C. "Automation and Management," Advanced Management Journal, April, 1964, 7-11.

LeGrand, Rupert. "Ford Handles by Automation," American Machinist, October, 1948, 107-122.

Moller, George. "Will Management in Smaller Companies Keep Pace with Automation," Advanced Management Journal, April, 1964, 45-50.

"Papermaking in Prodigious Proportions," Automation, January, 1970, 84-85.

Phatak, Arvind. "Managerial Attitudes in the United States and India," The Economic and Business Bulletin of Temple University, Summer, 1969, 15-21.

Rezler, Julius. "Managerial Functions in the Era of Automation," Advanced Management Journal, April, 1964, 57-65.

Smith, L. R. "We Build a Plant to Run Without Men," Magazine of Business, February, 1929.

Sultan, Paul E., and Prasow, Paul. "Automation: Some Classification and Measurement Problems," Automation: A Discussion of Research Methods. Labor and Automation Bulletin No. 1. Geneva: International Labor Office, 1964.

PUBLIC DOCUMENTS

U.S. Congress, Joint, Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report. Hearings on Automation and Technological Change. 84th Congress, 1st Session, 1955.

U.S. Congress, Senate, Subcommittee on Employment and Manpower of the Committee on Labor and Public Welfare. Nations Manpower Revolution. 88th Congress, 1st Session, 1963.

U.S. Congress. Senate, Subcommittee on Employment and Manpower of the Committee on Labor and Public Welfare. _Toward Full Employment: Proposals for a Comprehensive Employment and Manpower Policy in the United States._ 88th Congress, 2nd Session, 1964.

UNPUBLISHED MATERIAL

Hahn, K. Robert. "Outlook for the Automation Environment." Paper read before the Second Annual Symposium on Automation and Society, University of Georgia, Athens, Georgia, April 8, 1970.

Harrington, Joseph, Jr. "Keynote Address to the Second Annual Georgia-Reliance Symposium on Automation and Society." University of Georgia, Athens, Georgia, April 6, 1970.

Hedden, Russell A. "Management Attitudes Toward Automation." Paper read before the Second Annual Symposium on Automation and Society, University of Georgia, Athens, Georgia, April 7, 1970.